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MONOGRAPH

ON THE

FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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CONTENTS

OF THE

MONOGRAPH ON THE REPTILIA OF THE WEALDEN AND PURBECK FORMATIONS.

ORDER—CHELONIA. Family—PALUDINOSA . . Part I. Page 1

Pleurosternon, observations on genus	. .	,,	2
Pleurosternon concinnum	. . .	,,	3
,, emarginatum	. . .	,,	6
,, ovatum	. . .	,,	8
,, latiscutatum	. . .	,,	9
Chelone costata	. . .	,,	10
Platemys Mantelli	. . .	,,	11
Emys de Sussex	. . .	,,	,,
Emys de Mantelli	. . .	,,	,,
Platemys sp. dub.	. . .	,,	,,
,, Dixoni	. . .	,,	12

ORDER—DINOSAURIA.

Iguanodon, introduction to general description of skeleton of		Part II.	1
,, cervical vertebræ	. .	,,	2
,, ribs	. . .	,,	7
,, sacrum	. . .	,,	8
,, sacral vertebræ	. .	,,	14
,, caudal vertebræ	. .	,,	15
,, skull	. . .	,,	18
,, lower jaw	. . .	,,	20
,, upper jaw	. . .	,,	26
,, teeth	. . .	,,	30
,, scapula, coracoid, and humerus	.	,,	32
,, pelvis	. . .	,,	35
,, femur	. . .	,,	36
,, tibia and fibula	. .	,,	39
,, metatarsal and phalangeal bones	.	,,	40
,, integument (?)	. .	,,	51
,, size	. . .	,,	52
Megalosaurus, general description of skeleton of	.	Part III.	1
,, dorsal vertebræ	. .	,,	4
,, sacral vertebræ	. .	,,	7
,, ribs	. . .	,,	12

Megalosaurus, scapula	Part III.	Page 13
„ coracoid	„	14
„ clavicle	„	16
„ ischium	„	„
„ femur	„	17
„ tibia	„	18
„ ungual phalanges	„	19
„ mandible and teeth	„	20
„ size	„	24
„ strata and localities	„	25
Hylæosaurus, introduction to description of skeleton of	Part IV.	8
„ sacrum	„	12
„ caudal vertebræ	„	15
„ scapular arch	„	16
„ tibia	„	17
„ metapodium	„	18
„ jaw	„	19
„ teeth	„	21
„ dermal scutes	„	22
„ dermal spines (?)	„	23

ORDER—LACERTILIA.

Nuthetes destructor	Part V.	31
Saurillus obtusus	„	33
Macellodon Brodiei	„	„
Echinodon Becklesii	„	35

ORDER—DINOSAURIA.

Iguanodon, restoration of the hind (?) foot	Sup. I.	1

ORDER—CROCODILIA.

Streptospondylus, observations on genus	Sup. II.	20
Streptospondylus major	„	22
„ „ cervical vertebræ	„	„
„ „ dorsal vertebræ	„	„
Cetiosaurus, observations on genus	„	27
„ dorsal vertebræ	„	28
„ caudal „	„	„
„ strata and localities	„	35
Pelorosaurus, observations on genus	„	36
Pelorosaurus Conybearii	„	38
„ „ humerus	„	39
Tooth of unknown Wealden Reptile	„	42

ORDER—DINOSAURIA.

Iguanodon, mandible	Sup. III.	19

INDEX

TO THE

SPECIES DESCRIBED IN THE MONOGRAPH

ON THE

REPTILIA OF THE WEALDEN AND PURBECK FORMATIONS.

Cetiosaurus brevis, ***Owen***, Weald. **Sup. No. 2, p. 27, tabs. viii, ix, x.**

Chelone costata, ***Owen***, Weald. **Part I, p. 10, tabs. viii, ix, fig. 4.**

Echinodon Becklesii, ***Owen***, Purbeck. **Part V, p. 35, tab. viii, figs. 1—9.**

Emys de Sussex, Weald., ***Cuvier***. **Part I, p. 11.**

Emys Mantelli, Weald., ***E. Gray***. **Part I, p. 11.**

Hylæosaurus armatus, ***Mant.***, Weald. **Part IV, p. 8, tabs. iv—xi.**

Iguanodon Mantelli, ***Meyer***, Wealden and Greensand. **Part II, p. 1, tabs. i—xviii.**

„ „ „ „ **Sup., No. 1, p. 1, tabs. i—iii.**

„ „ „ „ **Sup., No. 3, p. 19, tab. x.**

Macellodon Brodiei, ***Owen***, Purb. **Part V, p. 33, tab. viii, fig. 10.**

Megalosaurus Bucklandii, ***Meyer***, Oolite and Wealden. **Part II, tab. xix. Part III, p. 1, tabs. i—xii.**

Nuthetes destructor, ***Owen***, Purb. **Part V, p. 31, tab. viii, figs. 1—9.**

Pelorosaurus Conybearii, ***Mant.***, Weald. **Sup., No. 2, p. 36, tabs. xi, xii.**

Platemys Dixoni, ***Owen***. **Part I, p. 12, tab. ix, fig. 3.**

Platemys Mantelli, ***Owen***, Weald. **Part I, p. 11, tab. ix, fig. 1.**

Platemys sp. Weald. **Part I, p. 11, tab. ix, fig. 2.**

Pleurosternon concinnum, ***Owen***, Purb. **Part I, p. 3, tabs. ii and iii.**

„ **emarginatum**, ***Owen***, Purb. **Part I, p. 6, tabs. iv, v, and vi.**

„ **latiscutatum**, ***Owen***, Purb. **Part I, p. 9, tab. i.**

„ **ovatum**, ***Owen***, Purb. **Part I, p. 8, tab. vii.**

Saurillus obtusus, ***Owen***, Purb. **Part V, p. 33.**

Streptospondylus major, ***Owen***, Weald. **Sup., No. 2, p. 22, tabs. v, vi, vii, figs. 1—3.**

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

PART I.

PAGES 1—12; PLATES I—IX.

CHELONIA (PLEUROSTERNON, &c.)

[PURBECK.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

Issued in the Volume for the Year 1853.

LONDON:
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1853.

MONOGRAPH

ON THE

FOSSIL CHELONIAN REPTILES

OF THE

WEALDEN CLAYS AND PURBECK LIMESTONES.

ORDER—*CHELONIA.*

FAMILY—PALUDINOSA.

Genus—PLEUROSTERNON.[1]

In acquiring the requisite materials for the present Monograph, I have had under examination numerous Chelonites from the Wealden series, the majority of which, as in most of the secondary rocks, were more or less fragmentary; indicating, indeed, with sufficient certainty, the order of Reptiles to which they had appertained, but not so perfect as to yield the characters required for determining the family of Chelonia to which they had belonged, much less their relations to the known species of tertiary and existing Tortoises and Turtles.

From the above series of Wealden Chelonites, I have selected for description and delineation those specimens which seemed best to illustrate the nature of the house-carrying Reptiles of the period; and propose to commence with the more perfect specimens which have been extracted from the fresh-water limestones of the Purbeck beds. For the opportunity of examining and figuring the best preserved examples of this kind, I am more especially indebted to William Cunnington, Esq., of Devizes, and to Charles Willcox, Esq., M.R.C.S., of Swanage, Dorsetshire.

[1] Derivation—πλευρον a rib, στερνον the breast-bone.

Genus—PLEUROSTERNON.

Char. Gen.—Testa depressa lata, complanata; sternum integrum, ossibus undecim compositum, per ossiculis marginalibus cum testá conjunctum; scutis submarginalibus inter scutá axillariá et inguinaliá positis.

As a general rule the vertebrate animals of the secondary strata manifest, in the modifications of their structure, a nearer approach to the archetype of their sub-kingdom than the tertiary and existing vertebrates do. This rule is exemplified in the present genus of Chelonian Reptiles by the accessory osseous pieces that enter into the formation of the plastron, and which are interposed, as an additional pair of bones, between those more constant parial elements called "hyosternals" (*h s*, Tab. III) and "hyposternals" (*p s*, ib.), and which alone articulate with the marginal pieces (*m, m*) in existing Emydians. At least, if we adopt the general homology of the parial elements of the plastron, indicated by the development of that part, viz. as being hæmapophyses,—an increased number of such pieces, making them to that degree more equal in number with the pleurapophyses of the carapace, offers an obvious tendency to a return to the normal type; and the fact of a genus or family of extinct secondary Chelonians manifesting such increase in the number of parial pieces, gives additional support to the conclusions as to the nature of the plastron, arrived at from a study of that part in the embryos of existing species.

By the name *Pleurosternon*, proposed for the remarkable extinct Chelonia about to be described, it is desired to intimate the characteristic furnished by the additional number of inferior rib-elements (hæmapophyses, or "cartilagines costarum" of Anthropotomy) composing the under-shell or plastron, which part naturalists, influenced by the views of Geoffrey St. Hilaire, have usually described under the arbitrary name of "sternum."

The extent of the ossification of the carapace and plastron, and the firm union of the roof and floor of the bony chamber by the medium of the side-walls, afforded by certain marginal plates, prove the genus not to belong to the *marine Chelonia;* the presence of the marginal plates, and the impressions of the horny scutes which covered the carapace and plastron, forbid its being referred to the *fluvial* tribe, represented by the *Trionyces;* the depressed shape of the carapace excludes it from the *terrestrial* tribe of true Tortoises; and we arrive, therefore, by the way of exclusion, to the association of the genus in question with the Terrapenes and other members of the family *Paludinosa* of the eminent Erpetologists, MM. Duméril and Bibron.

PLEUROSTERNON CONCINNUM. *Owen.* Tab^e II and III.

The first specimen of *Pleurosternon* which will be described in the present Monograph is one from the fresh-water limestone of Purbeck, which was kindly transmitted to me by Wm. Cunnington, Esq., for that purpose. It consists of a nearly entire carapace and plastron.

The carapace, Tab. II, includes the nuchal plate, *c h*; the eight neural plates, *s* 1—*s* 8, which are connate with the neural spines of the vertebræ of the carapace; and the corresponding eight pairs of costal plates, except the eighth on the right side, *pl.* 1—8. The hindmost neural plates, and all the marginal plates, save the first of the left side connected with the nuchal plate, are wanting.

The length of the carapace, from the anterior margin of the nuchal plate to the posterior one of the eighth neural plate, is 13 inches; the breadth of the carapace, across the third costal plates, is 11 inches. The outer surface of the carapace is very slightly convex.

The nuchal plate, *ch*, is six-sided; the anterior and antero-lateral borders are of equal length, and are the longest of the six; the hind border is the shortest: the latter is angularly notched for the reception of the first neural plate, *s* 1. The front border is slightly convex, with a feeble median concavity. The greatest breadth of the nuchal plate, which is across the angles between the antero-lateral and postero-lateral borders, is 3 inches 4 lines; the length of the nuchal plate is 2 inches 3 lines. The outer surface of the nuchal plate is impressed by a triradiate groove, indicative of the junction of the two nuchal scutes with each other and with the first vertebral scute, *v* 1. The portion of the median series of bony plates answering to the first neural plate in ordinary Chelonia is divided by a transverse suture into two plates,—a circumstance which corroborates the homology of the neural plates with the median dermal bones of the Crocodilia, and opposes their interpretation as the vertebral spinous processes unwontedly expanded. The indented boundary between the first, *v* 1, and second, *v* 2, vertebral scutes crosses the first neural plate, *s* 1, immediately in advance of the dividing suture in question.

The second, *s* 2, to the eighth, *s* 8, nuchal plates inclusive are six-sided, with the antero-lateral sides or borders the shortest, and the postero-lateral ones the longest; the third, fifth, and eighth are crossed by the boundary impressions between the vertebral scutes. They progressively diminish in length to the seventh; the eighth resuming the normal length, unless the indentation between the fourth, *v* 4, and fifth, *v* 5, vertebral scutes conceal, as I suspect, a suture dividing the plate, *s* 8.

The first pair of costal plates, *pl.* 1, is impressed by the boundary lines dividing the second marginal scute, the first vertebral scute, *v* 1, the second vertebral scute, *v* 2, and the first costal scute, *c* 1; it unites with the nuchal, *c h*, and first and second mar-

ginal plates, with both divisions of the first neural plate, *s'*, with the anterior truncated angle of the second neural plate, *s* 2, and with the second costal plate, *pl.* 2; the second, *pl.* 2, to the seventh, *pl.* 7, costal plates, have the posterior angle of their mesial extremity truncated; they become slightly expanded at their lateral extremity; and, after the third, they gradually decrease in length. The second, fourth, and sixth costal plates, like the first costal plate, bear the impressions of the lines of union of the costal scutes with each other and with the vertebral and marginal scutes: the third, fifth, and seventh costal plates bear the impressions of the lines of union of the costal with the vertebral and marginal scutes. The eighth costal plate is impressed by the line of union between the fourth costal scute and the fifth vertebral scute, and by that of both these scutes with the fourth vertebral scute mesially, and with the tenth marginal scute laterally.

The exterior surface of all the above-described elements of the carapace is minutely wrinkled and granulated, except near the sutural borders, where it is impressed by numerous close-set fine lines, directed at right angles, or nearly so, with those borders. This two-fold pattern is best marked in the costal plates, in most of which the marginal lineated sculpturing extends over about one fourth of the entire breadth of the scute. There are no concentric impressions indicative of the lines of growth of the horny scutes.

The first marginal scutes meet at the middle line on the forepart of the nuchal plate, and do not leave there any median or nuchal scute in the present species. The first and second vertebral scutes are of equal breadth, the succeeding three progressively decrease in breadth: all are six-sided, and broader than they are long, the length and breadth being most nearly equal in the fourth vertebral scute, *v* 4.

The following are the dimensions of the principal vertebral scutes:

	First.		*Second.*		*Third.*		*Fourth.*	
	In.	Lines.	In.	Lines.	In.	Lines.	In.	Lines.
Length, or antero-posterior extent .	2	6	2	11	2	11	3	0
Breadth	4	10	4	10	4	7	3	6

Their shape is sufficiently indicated in the figure, Tab. II; as is also that of the costal scutes, *c* 1 to *c* 4.

In the carapace above described, the greater part of the marginal plates, the eighth costal plate of the right side, and the terminal neural plates, are wanting; but sufficient remains in natural juxtaposition to show that the carapace has been of a full oval figure, broadest anteriorly, with a very slight degree of convexity, and without any special elevations along the median line or at other parts.

The plastron, Tab. III, is a long, rather narrow, flat, oval plate; it was probably rounded anteriorly, but this border is fractured: it contracts from the lateral wall, *h s*, *p s*,

and covered the posterior half of the hyosternals and the anterior third of the mesosternals. The abdominal scutes, *a b*, presented a similar form, and covered the rest of the mesosternals and less than half of the hyposternals. The femoral scutes, *fe*, were longer than they were broad; they joined the abdominal scutes by a straight transverse line; but that between them and the anal scutes, *an*, describes a curve, with the convexity backwards, and nearly equally divides the xiphisternals, *xs*. In addition to the axillary and inguinal scutes, there are three scutes interposed between the outer borders of the pectoral and abdominal scutes, and the under borders of the fifth, sixth, and seventh marginal scutes: these superadded scutes I propose to call "submarginal scutes." The *Platysternon megacephalum*, or Large-headed Terrapene of the Chinese swamps, presents a corresponding, but single, supplementary "submarginal scute," upon the under part of each lateral production of the plastron. The under surface of the fifth, sixth, and seventh marginal plates bears a crucial impression, indicative of the lines of junction between the marginal and submarginal scutes. The head of the left femur is preserved, near the seventh marginal plate, in the specimen above described.

For the species of *Pleurosternon*, which the above-described specimen, Tab[æ] II and III, represents, I propose the name of *concinnum*.

PLEUROSTERNON EMARGINATUM. *Owen.* Tab[æ] IV, V, and VI.

A nearly-allied species, *Pleurosternon emarginatum*, is represented in Tab[æ] IV, V, and VI. It is from the same formation and locality, and differs from the foregoing chiefly in the contour of the free borders of the plastron. The anterior and posterior marginal plates being preserved in the specimen figured in Tab. IV, and almost all those of the right side in that figured in Tab. V, we obtain a nearly complete idea of the contour of the carapace in this broad and depressed extinct species of Emydian. The nuchal and first marginal scutes are unluckily wanting in the specimen with the upper surface of the carapace exposed, which prevents our determining whether the present species possessed or not the nuchal scute. The neural plate answering to *s* 1 in ordinary Chelonia is divided by a transverse suture in this species, as in *Pl. concinnum*, Tab. II; and the impression of the line of union between the first and second vertebral scutes crosses just in front of the suture of division. The second neural plate, 2, joins the first costal plate of the left side, but not that of the right; and it is pentagonal, the shortest side or border being that which joins the left first costal plate. The third, 3, to the seventh, 7, neural plates inclusive are hexagonal, and resemble in shape those in the *Pleurosternon concinnum;* the eighth neural plate is hexagonal, and is broader than it is long; the ninth neural plate, answering to that bearing the letter *s* 8 in Tab. II, is more expanded at its hinder part; the tenth neural plate, 10, is triangular,

with a truncated apex and a broad rounded base, which articulates with the pygal and adjoining marginal plates.

The costal plates offer nothing particularly worthy of note, in comparison with those of *Pleurosternon concinnum.*

The second and third marginal plates bear not only the impressions of the lines dividing the corresponding marginal scutes from each other, but those dividing the marginal from the first costal scutes. The succeeding costal scutes do not encroach on the marginal plates, which consequently only show the impressions dividing the marginal scutes from each other. Some of the marginal scutes are slightly dislocated, and the posterior ones, from the ninth to the pygal scute inclusive, have their free borders mutilated.

The first vertebral scute, *v* 1, is narrower than the second and third vertebral scutes, instead of being broader, as in *Pleurosternon concinnum.* The second vertebral scute, *v* 2, is proportionally broader behind than is its homologue in *Pl. concinnum.* The fifth vertebral scute, *v* 5, has the three angles of its hinder border sharply produced in the interspaces between the last marginal scutes.

The character of the outer surface of the carapacial pieces resembles that in the *Pleurosternon concinnum.*

The more entire posterior border of the carapace, of which the inner surface is exposed in the specimen figured in Tab. IV, shows it to be slightly emarginate at the middle of that border; and there is sufficient of the anterior border of the same carapace preserved to show that it is more widely and deeply emarginate at the middle of that end.

With regard to the plastron, the lateral borders of the anterior freely-projecting portion are straighter, and those of the posterior portion more uniformly convex, than in the *Pleurosternon concinnum;* the terminal notch has its sides concave instead of convex. The impression of the line dividing the humeral, *hu*, from the pectoral, *pe*, scutes advances at the median plane so as almost to touch the entosternal, *s*. The mesosternals differ from those of the *Pl. concinnum* by the right extending a little to the left of the median line, but not more than may be expected from the admitted extent of variety in different individuals of the same species. The line between the femoral, *fe*, and anal, *an*, scutes is wavy, instead of being simply convex, as in *Pl. concinnum.* The impressions of the three accessory (submarginal) scutes, between the axillary and original scutes, on the right side of the plastron, Tab. VI, are well shown; they have not encroached so far upon the marginal plates as in the *Pl. concinnum.*

The length of the carapace of the *Pleurosternon emarginatum*, in the specimen figured in Tab. IV, is 21 inches 9 lines; the breadth of the carapace is 20 inches. In the specimen figured in Tab$^{\text{æ}}$ V and VI, the breadth seems to have been less; but allowance must be made for the partial dislocation inwards of the broad marginal plates, which,

on the right side, overlap the ends of the costal plates. The entire length of the carapace of this specimen seems to have been about 17 inches; the breadth about $15\frac{1}{2}$ inches.

PLEUROSTERNON OVATUM. *Owen.* Tab. VII.

The most beautiful and perfect example of the depressed Emydians, with the complex plastron, from the fresh-water limestone of Purbeck, is that from the collection of Charles Willcox, Esq., M.R.C.S., which, by the liberality of its possessor, has been figured, in Tab. VII, for the present Monograph.

The entire series of marginal plates is preserved with scarcely any dislocation or fracture, in natural connection with the costal plates: they show the carapace to have been nearly elliptical in figure, but a little more pointed, or less obtusely rounded behind than before; it is not emarginate at the anterior border, and was only very slightly so, if at all, at the posterior border. The *Pleurosternon concinnum* resembles the *Pleurosternon ovatum* in the absence of the anterior emargination of the carapace, which distinguishes the *Pleurosternon emarginatum.* The first vertebral scute, *v* 1, is, however, as in that species, narrower than the second, instead of being of equal breadth, as in the *Pl. concinnum:* it covers, also, a larger proportion of the first neural plate, *s* 1, which, moreover, is not divided into two, as in the two previously described species. The place of the fourth neural plate is occupied by the conjoined median ends of the fourth pair of costal plates, ossification having extended continuously from them into the dermal matrix overlying the subjacent neural spine, instead of commencing from that spine or from a separate centre; but this may be an individual variety. It leads, however, to a modification of form of the fifth neural plate, *s* 5, which is pentagonal, instead of being six-sided, as is usual, and as is the case with the two succeeding neural plates. The eighth neural plate expands posteriorly, and the expansion in this direction is progressive in the ninth and tenth neural plates; the eleventh or pygal plate, *py*, is narrower than the back part of the tenth neural plate, is quadrate, and shows, both by its shape, size, and median impression, that it belongs rather to the category of the dermal marginal plates, the series of which it completes posteriorly. The costal plates, *pl.* 1 to *pl.* 8, offer no modification worthy of notice. There are eleven marginal plates, 1, 1′, to 10, on each side of the carapace, in addition to the nuchal, *ch* and pygal, *py*, plates; they increase in breadth after the sixth; the first bears the impression of the triradiate line which marks the division between the first, *m* 1, and second, *m* 2, marginal scutes, and the first, *v* 1, vertebral scute.

There was no nuchal scute. The second, third, and fourth marginal plates were slightly overlapped by the first costal scute, *c* 1. The antero-posterior breadth, in comparison with the transverse breadth, is greater in the costal scutes of the *Pleurosternon*

these fossils is represented, of half the natural size, in Tab. I. This specimen is now preserved in the Museum of the Philosophical and Natural History Society of Dorchester.

CHELONE COSTATA. *Owen.* Tab. VIII.

From the Wealden Clays of Tilgate Forest have been obtained many fragmentary Chelonites, indicative of species representing two of the actual families of the order, viz. *Paludinosa* and *Marina;* and such, therefore, as might be expected to be met with in the deposits of a large estuary. I propose to commence the description of these Wealden Chelonites by those which indicate a species of the marine family.

Portions of the carapace and plastron, and bones of the extremities of a large species of Turtle, some of them indicating individuals with a carapace nearly three feet in length, form part of the Mantellian collection, purchased by the British Museum: a few of these Chelonites have been figured in Dr. Mantell's 'Illustrations of the Geology of Sussex,' 4to, 1822.

The author of that work has not deduced any specific characters from these fossils, and the nature of most of the specimens hardly allowed their determination to be carried closer than to the marine family of *Chelonia.*

With regard to one of the specimens (Pl. VI, fig. 2), however, Mr. Clift's authority is quoted for its resemblance with the corresponding part of the *Chelone imbricata,* and Dr. Mantell acknowledges that "as Cuvier had referred the turtles of Melsbrock to the *Emydes,* we at first entertained doubts whether our approximation of this specimen to the *Cheloniæ* were correct. Mr. Clift's remark, however, tends to confirm the opinion that it belongs to a marine turtle." (Op. cit., p. 62.)

After a careful comparison of the specimens in the British Museum, I have come to the conclusion that the Wealden species differs from the *Chelone imbricata, Chelone carinata,* and other recent species, in as great a degree as do most of the extinct *Chelones,* in the greater extent of ossification of the costal interspaces and of the plastron.

A characteristic portion of the great Wealden Turtle is represented, of the natural size, in Tab. VIII of the present Monograph. It includes the second and third marginal plates, and considerable portions of the first and second costal plates, with the connate portions of the pleurapophyses, or vertebral ribs. These are remarkable for their breadth and prominence, and have suggested the name proposed for the present species of Wealden *Chelone.*

In the same plate are represented a mutilated right iliac bone, fig. 3, and the right femur of, probably, the same species of Turtle. These, also, are from the Wealden formations of Tilgate Forest, and form part of the Mantellian Collection now in the British Museum.

Figure 4, Tab. IX, gives a view of the inner surface of the left hyposternal, half the natural size of, probably, the same species of *Chelone*. It is imbedded in a slab of Wealden stone.

As compared with existing Turtles, the ossification of the plastron is more advanced or more extensive, the rays of bone from the outer and inner free borders of the hyposternal being shorter and their interspaces more filled up. A nearer approach is thus made in this Wealden species, as in some of the Eocene Turtles, to what may be regarded as the more general type of the Chelonian carapace.

PLATEMYS MANTELLI. *Owen*. Tab. IX, fig. 1.

Report on British Fossil Reptilia, 1841, p. 167.
EMYS DE SUSSEX, *Cuvier*. Ossemens Fossiles, 4to, tom. v, part ii, 1824, p. 232.
EMYS MANTELLI, *J. E. Gray*.

Amongst the Chelonian Fossils obtained by Dr. Mantell from the Wealden strata of the Tilgate Forest, in Sussex, were certain specimens, the resemblance of which to the flat species of Emydian, or terrapene, discovered by M. Hugi in the Jura limestone at Soleure, has been pointed out by CUVIER, (loc. cit.) Both the Jura species and the Wealden Chelonites in question are referable to the 'pleuroderal' section of the great tribe *Paludinosa*, as arranged by Messrs. Duméril and Bibron;[1] and, in that section, to the genus *Platemys*, but so much of the skeleton has not, as yet, been discovered, as to afford a ground for a good specific character of the so-called *Emys Mantelli*.

The most intelligible fragment in the British Museum, is that element of the plastron—the hyosternal; which is figured in Tab. IX, fig. 1. The proportions of this bone indicate that the plastron of the *Platemys Mantelli* consisted of the ordinary nine pieces: where the accessory pair of mesosternal pieces is introduced, both the hyo- and hypo-sternals have relatively less antero-posterior extent than the fossil in question shows.

PLATEMYS, sp. dub. Table IX, fig. II.

A second species of Wealden *Platemys* is apparently characterised by a somewhat broader plastron, and by a greater relative thickness of the bones composing both this and the carapace. Without the latter difference, the proportionally broader plastron might be merely the sexual distinction of the female of the first species. Some difference, in the shape of the axillary notch of the hyosternal further induces me to regard the fragmentary Chelonites in question, of which a hyosternal is figured in Tab. IX, fig. II, as belonging to a second species of Wealden *Platemys*.

[1] Erpetologie, 8vo, 1835, tom. ii, pp. 172, 372.

PLATEMYS DIXONI. *Owen.* Table IX, fig. III.

A platemydian specifically distinct from either of the above is more unequivocally exemplified by the sternal element represented in Tab. IX, fig. III, the matrix having been carefully removed from the outer surface of this fossil, the linear impressions which have divided the humeral from the pectoral scute, and this from the abdominal scute, are clearly shown. The positions of these transverse grooves accord with those in the hyosternal of the Emydians, having the usual number (nine) of plastral elements: and the hyosternal character of the fossil is further shown by the oblique border cutting off the inner angle of the anterior end, for articulation with the entosternal element. (This end has been figured downwards in the plate.) The axillary groove is narrower than in the above-described species; and the whole bone seems to have been longer in proportion to its breadth. It is from the Wealden of Tilgate Forest, and is now in the British Museum. I propose to dedicate the Wealden terrapene, indicated by the above-described fossil, to my late esteemed friend, Frederic Dixon, Esq., F.G.S., author of the beautiful work 'On the Cretaceous and Tertiary Formations of Sussex.'

TABLE I.

HALF NAT. SIZE.

The carapace of *Pleurosternon latiscutatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

T. I.

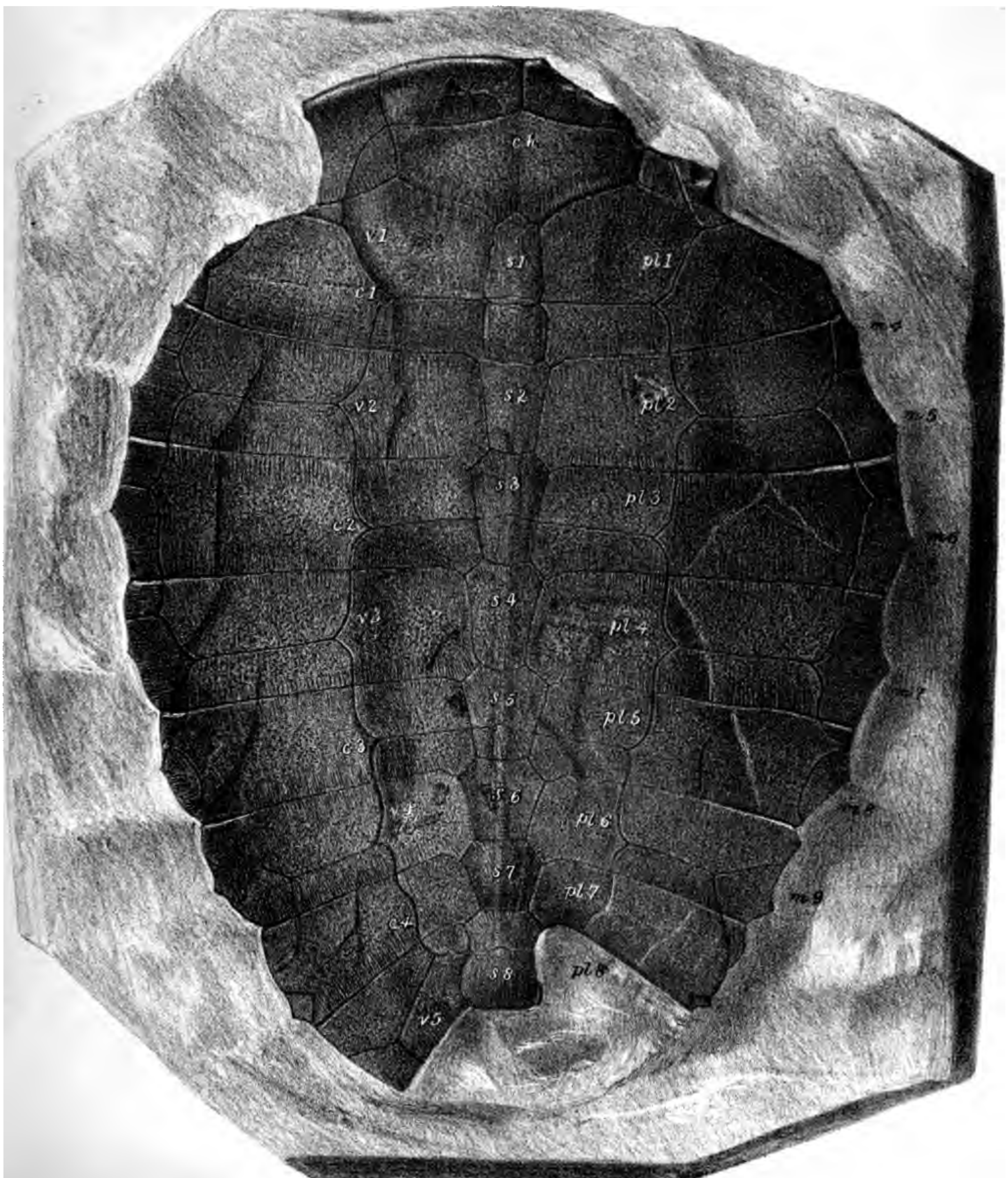
J. Dinkel del. et lith.

Day & Son, lith^rs to the Queen

TABLE II.

HALF NAT. SIZE.

The carapace of *Pleurosternon concinnum.* (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of William Cunnington, Esq., of Devizes, Somersetshire.



ck
v1
s1
pl1
c1
m4
s2
v2
pl2
m5
s3
pl3
c2
m6
s4
v3
pl4
m7
s5
pl5
c3
s6
v4
pl6
m8
s7
pl7
c4
m9
s8
pl8
v5

1/2

TABLE III.

HALF NAT. SIZE.

The plastron of *Pleurosternon concinnum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of William Cunnington, Esq., of Devizes, Somersetshire.

TABLE IV.

ONE THIRD NAT. SIZE.

The inner surface of the carapace of *Pleurosternon emarginatum*. From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

TABLE V.

HALF NAT. SIZE

The carapace of *Pleurosternon emarginatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

TABLE VI.

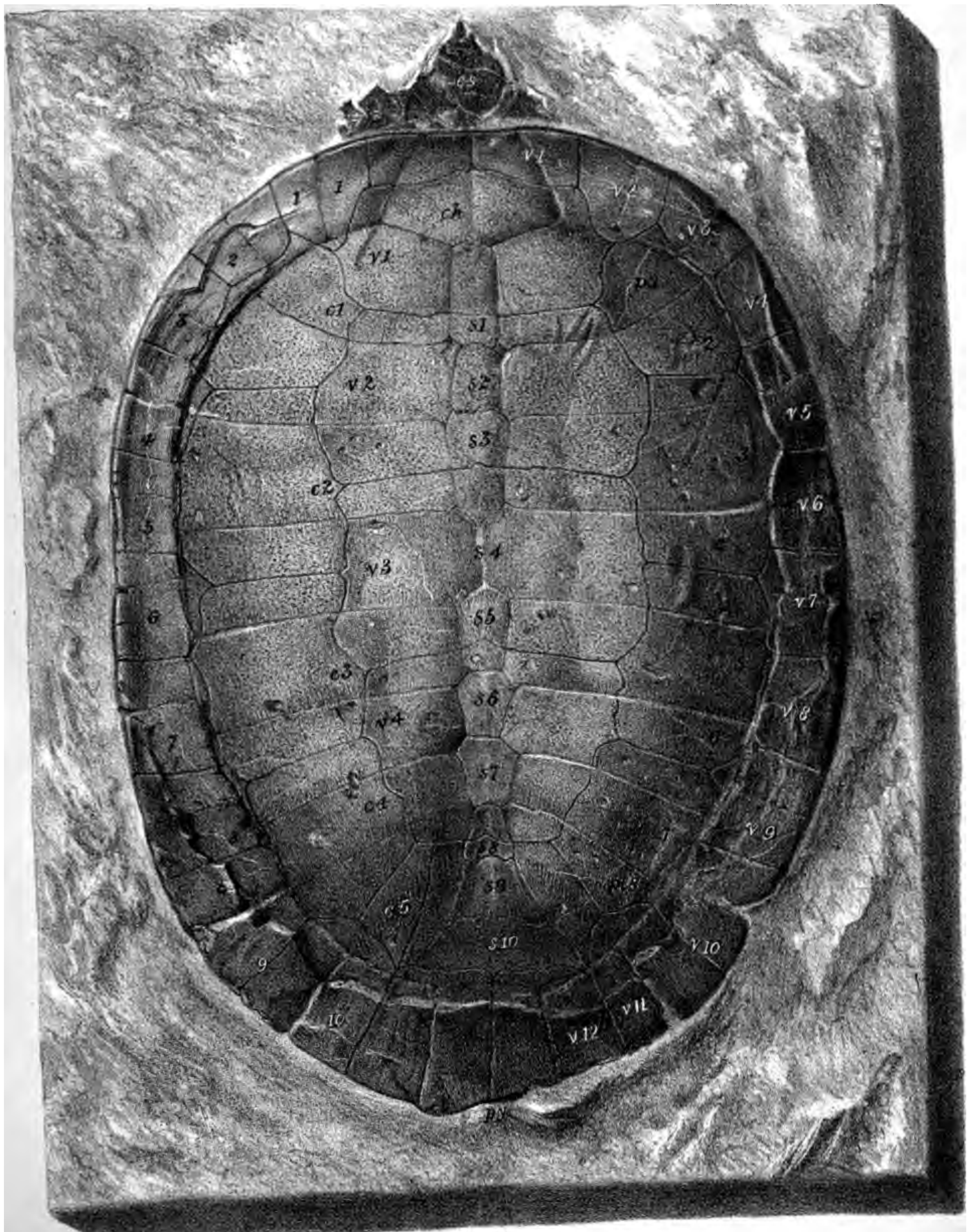
HALF NAT. SIZE.

The plastron and marginal plates of *Pleurosternon emarginatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

TABLE VII.

ONE THIRD NAT. SIZE.

The carapace of *Pleurosternon ovatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.



1/3

Jos. Dinkel, del et lith.

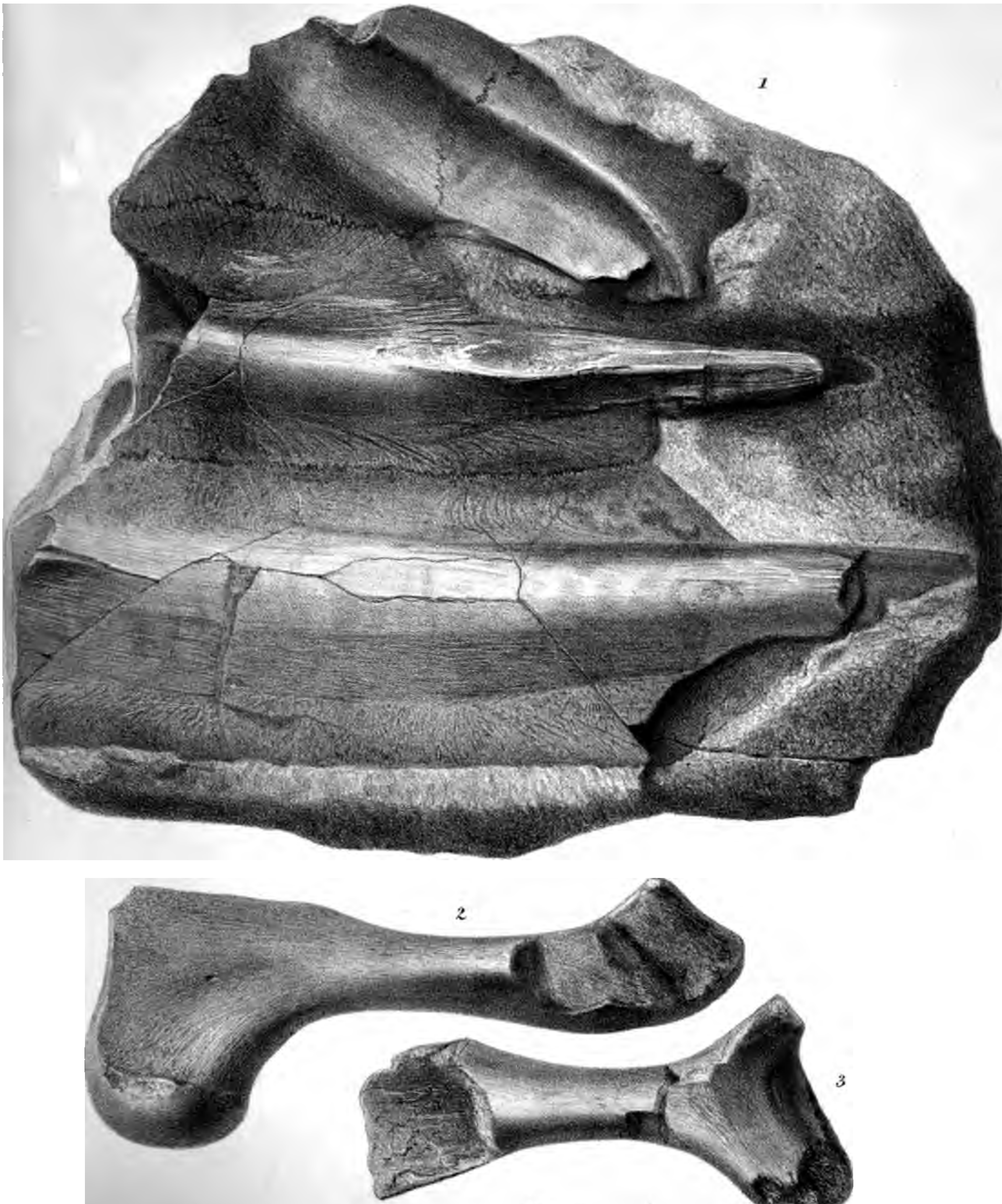
Day & Son. Lith.rs to The Queen.

TABLE VIII.

Fig. 1. Inner surface of a portion of the carapace of *Chelone costata*, nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 2. The right femur of *Chelone costata*, nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 3. The right iliac bone of *Chelone costata*, nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.



Nat. size.

Jos. Dinkel del. et lith.

Day & Son Lithrs to The Queen

TABLE IX.

Fig. 1. The inner surface of the right hyosternal bone of *Platemys Mantelli;* half nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 2. The inner surface of a portion of a hyosternal bone of another species of *Platemys;* half nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 3. The left hyosternal bone of *Platemys Dixoni;* half nat. size; (figured upside down.) From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

MONOGRAPH

ON THE

FOSSIL REPTILIA

OF

THE WEALDEN FORMATIONS.

ORDER—*DINOSAURIA*.*

(Cervical and anterior dorsal vertebræ with parapophyses and diapophyses; dorsal vertebræ with a neural platform; sacral vertebræ exceeding two in number; body supported on four well-developed unguiculate limbs.)

Genus—IGUANODON.

Dentes incrassati, marginibus lammellosis.

In a former Monograph 'On the Fossil Reptilia of the Cretaceous Formations,' 4to, 1851, p. 105, the vertebral characters of the dorsal and caudal regions of the spine of the Iguanodon were described and figured, as they were exhibited in the instructive specimen obtained by Mr. W. H. Bensted, from a Green Sand formation near Maidstone; in the present Monograph it is proposed to illustrate the characters of the rest of the skeleton, so far as undoubted parts of it have been obtained from the Wealden Strata, in which the first evidences of the Iguanodon were discovered by Dr. Mantell, and from which the most abundant and varied remains of this remarkable herbivorous reptile have since been obtained.

* Report on British Fossil Reptiles, 1841, in 'Trans. Brit. Association,' 8vo, 1842, p. 102. Pictet, 'Traité Elémentaire de Palæontologie,' 8vo, tom. ii, 1845, p. 52. From the Greek δεινὸς, fearfully great; σαῦρος, a lizard.

Description of part of the Skeleton of a Young Iguanodon. Tab. I.

IGUANODON MANTELLI, *Mantell.*

A considerable and very instructive part of the skeleton of a young Iguanodon, the entire body of which was probably under two yards in length, was discovered in the Wealden formations, about one hundred yards west of Cowleaze Chine, on the south-west coast of the Isle of Wight, in the year 1849.

The mass of Wealden stone in which this skeleton was imbedded, was broken into two parts in its extraction from the bed; and, as happened with the skeleton of the Dolichosaurus, described in a former Monograph,* the workmen disposed of one part to one collector, and of the other to another. Mr. Bowerbank was so fortunate as to become the possessor of that portion which contained the most important part of the skeleton, and which forms the upper division of the chief figure in the plate, Tab. I, where it is represented of the natural size.

This portion includes seventeen vertebræ, extending from the neck to near the pelvis inclusive: the pelvis apparently forms a continuation of the vertebral series, but is obscured by the principal bones of the right hind foot, *mt*, *pl*, 1 and 2. Some portions of ribs, *pl*, *pl*, and of a coracoid, 52, in the proximal part of the left femur, 65, the distal halves of the right tibia, 66, and fibula, 67, and a fragment of the left tibia, 66, are also imbedded in the same block of stone. The other portion of the block fell into the possession of Dr. Mantell, and is now in the British Museum. It includes eleven consecutive caudal vertebræ, with some of their hæmapophyses, *h*, *h*; the right femur, 65, the proximal halves of the right tibia, 66, and fibula, 67, and parts of the left tibia, 66′, and fibula, 67′. The bones of the right hind leg are almost completed when the blocks containing their opposite ends are brought into juxtaposition, as in Tab. I.

Of the seventeen vertebræ, in Mr. Bowerbank's specimen, the three anterior, 1, 2, 3, have been detached and carefully worked out: they appear to have immediately preceded the rest which remain imbedded in the block, and which are unequivocally consecutive; including the detached three, the seventeen vertebræ occupy an extent of thirteen inches.

The first three vertebræ, as imbedded and naturally cemented together, exhibit a slight upward curvature, and the five following vertebræ are bent in the same direction, but in a less degree: the rest present a moderate bend with the concavity downwards or towards the abdomen. The whole of this series, therefore, describes a gentle sigmoid curvature, like that which may be observed in the naturally articulated

* 'Fossil Reptilia of the Cretaceous Formations,' 1851, 4to, p. 22. Cuvier had to contend with similar difficulties; see 'Ossem. Foss.,' t. v, pt. ii, p. 148.

The following are the characters of the cervical vertebræ in Mr. Bowerbank's young Iguanodon:

The centrum partakes of the characteristic of that part in the dorsal region, in its lateral compression and the convergence of its sides to a very narrow inferior surface: but this wedge-shaped characteristic is exaggerated in the present vertebræ; the sides are naturally more compressed between the fore and hind articular ends; they are concave, not only lengthwise but vertically, and they meet below at a ridge from which a process—the hypapophysis—appears to have descended; for, though the ridge itself, *hy*, figs. 2 and 4, extends below the level of the articular ends of the centrum, it shows a fractured edge; and the hypapophysis is the characteristic of the cervical region in most saurian reptiles. As the neural canal retains its original capacity—the arch showing no marks of pressure,—the compression of the middle part of the sides of the centrum cannot be regarded as the effect of crushing; it is the same on both sides, and the expanded articular ends seem to exhibit their natural and symmetrical form,* as in fig. 4, Tab. I. This form differs from that in the dorsal region,† by being narrower in proportion to its depth, and repeats in this proportion the character of the same part in the caudal region;‡ but the contour of the cervical centrum is different from that of the caudal one: the anterior surface resembles an ancient shield, the sides slightly diverging as they descend to the parapophyses, and then more rapidly converging to the inferior ridge; the contour of the hinder surface, fig. 4, is an oval, a little flattened above at the larger end. The deep pit at the side of the centrum characteristic of the cervical and anterior dorsal vertebræ of the Streptospondyl is not present in the corresponding vertebræ of the Iguanodon. In these vertebræ the anterior articular surface is nearly flat vertically, very slightly concave at the middle, and as feebly convex above and below. Transversely the surface is slightly convex, and most so where it is continued, just above the middle of the surface, upon the parapophyses. The hinder surface is gently and pretty uniformly concave.

Both surfaces are devoid of that smooth or polished character which is observable in the Reptiles that have those surfaces coated by articular cartilage, and have their vertebral centrums articulated by synovial capsules; concentric striæ are plainly manifest near the border of the articular surface, whence I conclude that the vertebral bodies of the Iguanodon *were coarticulated by means of an intervertebral ligamentous substance, as in the class Mammalia.* That such substance intervened between these

* The assertion in the paper above cited, 'Phil. Trans.,' 1849, p. 303, that the three vertebræ here described "have been crushed and compressed almost flat laterally" has reference to an idea that they were homologous with the Streptospondylian vertebra described in my 'Report,' p. 92, the different form and proportions of which are explained by the authors of that paper on the assumption that that vertebra "has been compressed in an opposite direction," ib. p. 303.

† 'Mon. Cretaceous Reptiles,' tab. xxxvi.

‡ Ib., tab. xxvii.

origin in all the three detached vertebræ: there is a deep angular depression behind its base, between the two converging ridges from the posterior zygapophyses, probably for the implantation of an elastic ligament.

The proximal end of a slender pleurapophysis, *pl.* fig. 2, adheres by the matrix to the left side of the second and third of the three vertebræ above described; the neck of the rib is moderately long and rounded, truncate, and not expanded at its articular end; the tubercle is produced, and beyond that the rib becomes compressed: unfortunately only a small part of the body of the rib is preserved.

Of the succeeding vertebræ, imbedded in the matrix, the flat or slightly concave character is resumed in the anterior surface of the centrum of the third, counting backwards.

The modification of the articular terminal surfaces, slight as it is in the cervical vertebræ above described, may be readily understood to relate to the corresponding increase in the extent and facility of motion of that part of the spine. But such modification gives no support to the idea that the vertebra, No. $\frac{116}{2116}$ in the British Museum, provisionally referred to the *Streptospondylus major* in my 'Report on British Fossil Reptiles,' p. 92, but with the intimation of its being possibly a cervical vertebra of the *Cetiosaurus brevis* (ib., p. 96),—and referred by Dr. Mantell to the *Iguanodon Mantelli* in the 'Geology of the South East of England,' 8vo, 1833, p. 300, and by Dr. Melville to the same reptile, in the 'Phil. Trans.,' 1849, p. 301, Pl. XXVIII, fig. 4,—really appertained to the cervical region of the Iguanodon.

We have not, as yet, any evidence of so marked and sudden a change in the forms and proportions of a cervical vertebra, between the dentata and the fourth or fifth, occurring in any reptile or mammal, as would be the case were the vertebræ, described in p. 92 of my 'Report,' to belong to the Iguanodon; and the absence of such evidence prevents me now, as at the period when those vertebræ were first described, from hazarding or acceding to the hypothesis.

In the vertebræ succeeding those, 1, 2, 3, here regarded as cervical in the young Iguanodon, Tab. I, the sides of the centrum continue to be compressed, with a surface flat vertically, and concave longitudinally, and meeting below at a ridge, as far as the twelfth, counting backwards, and including the three detached cervicals: at the fourteenth vertebra the lower part of the centrum is broader, and is convex transversely. The parapophysis has ascended upon the neurapophysis in the fifth vertebræ, counting backwards; and in the sixth the contour of the articular terminal surface is oval, with the small end downwards: it is shown to be elliptical in the sixteenth vertebra.

The neurapophysial sutures are retained throughout the series of the seventeen successive vertebræ. In the seventh, sufficient of the neural arch is preserved to show the interzygapophysial ridge, forming the base of the expanded bony platform, *n*; a part of the neural spine, *n* 5, of this vertebra is preserved, to an extent equaling the vertical diameter of the rest of the vertebræ: it is compressed, but of considerable

in Tab. II, figs. 1 and 2. The neck is less distinct from the tubercle and body than in other ribs which seem to have been situated further back; it expands more gradually to the tubercular articulation with the diapophysis, and is at this part 5 inches in breadth; it bends with a deep oblique curve for about one fifth of its length, and then is continued in a nearly straight line to its extremity: this is slightly expanded and truncated, for the attachment doubtless of a bony sternal rib. The convex or outer margin of the rib is bent backwards so as to overhang the sub-compressed shaft of the bone along its upper or proximal third part.

The proximal extremity of one of the ribs from the middle of the trunk of the Horsham Iguanodon, presents an ovate head 2½ inches in the long diameter; the neck is 7 inches long, straight, compressed, and topped by a well-marked tubercle, where it joins the body of the rib. This part is also compressed; and its external margin, besides being bent backwards, is also developed in the contrary direction, so as to assume the form of a slightly convex plate of bone 2 inches broad, attached at right angles to the shaft of the rib, which it overhangs on both sides. This structure is characteristic also of some of the ribs in the other Dinosaurs, and is interesting as indicating the commencement of that peculiar development of the corresponding part of the ribs in the Chelonian reptiles, by which, and their connexion with continuous dermal ossifications, the lid of their bony box is almost wholly formed.

In fig. 3, Tab. II, is given a view of the upper surface of the head, neck, and tubercle, and expanded beginning of the shaft of a rib of an enormous Iguanodon, the part so represented measuring 10 inches in a straight line. A ridge is developed from the upper surface which, at the tubercle, expands into the overhanging plate of bone. In a more posterior rib, figs. 4 and 5, the tubercle is more distinctly developed, and continues so to be as the neck progressively shortens, as in figs. 6—10, Tab. II. Fig. 8 gives a view of an almost entire pleurapophysis, or "vertebral" rib, from about the middle of the thoracic abdominal cavity, the length of which, in a straight line, from the tubercle to the fractured end of the body, is 32 inches. The common form of the body of the rib is that exemplified in the transverse section of the rib, given at fig. 1. The number of thoracic abdominal vertebræ, supporting such free and more or less elongated ribs, was probably about fifteen.

Sacrum of the Iguanodon. Tab. III, IV, V and VI. (Half nat. size.)

The facts ascertained relative to the structure of that part of the vertebral column, answering to the "true vertebræ" in Human Anatomy, of the Iguanodon, had tended, at the period of preparing my 'Report on British Fossil Reptiles,' in 1840, to rectify the ideas on the Lacertian affinities of that reptile, suggested by its name, and had proved the Iguanodon to belong to a more highly organized section of the then-defined Saurian

compared with the sacrum of the *Megalosaurus*, which I had about the same time determined:

"This instructive specimen consists of five vertebræ anchylosed together by the articular surfaces of their bodies, and by their spinous processes, which seem to form a continuous thick median ridge of bone. The articular extremity of the terminal sacral vertebra is very slightly concave and subcircular, measuring 3 inches in both vertical and transverse diameter. The bodies of the vertebræ are compressed at their middle part, and broader below than in the dorsal region, and concave in the direction of their axis, the concavities being separated by the broad prominent convex transverse ridges formed by the anchylosed and ossified intervertebral spaces. The contour of the under part of the sacrum thus forms an undulating line. The lateral and inferior surfaces are separated by a more angular prominence of the centrum; the under surface is less convex transversely, and the whole centrum is shorter in proportion to its depth and breadth, than in the *Megalosaurus*. The neurapophyses present the same remarkable modification in regard to their relations to the body of the vertebra as in the *Megalosaurus*, having shifted their position from the upper surface of a single centrum to the interspace of two, resting on proportions of these, which are more nearly equal, as the vertebræ are nearer the middle of the sacrum. The nerves were compelled, therefore, to escape from the spinal canal over the body of the vertebra, more or less near its middle, and impress the upper surface there with a smooth canal. The strong, vertically compressed, transverse processes, or sacral ribs, rise from the bases of the neurapophyses, and their origin extends upwards upon the spine, and downwards upon the sides of the contiguous vertebral bodies and intervertebral space: in the specimen described they are firmly anchylosed to all these parts, extend outwards, and expand to their extremities, four of which meet, join, and form an elongated tract of varying breadth, to which the ilium is firmly attached.

"The length of the largest penultimate transverse process was 5 inches 8 lines, its vertical breadth at the middle 3 inches, its thickness here 1 inch. The adjoining (last) transverse process was 5 inches in length; the interspaces of the transverse processes equalled from 2½ to 2 inches. The sacrum increases in breadth posteriorly; its transverse diameter, including the anchylosed ilia taken at the posterior part of the acetabulum, is 13 inches, at the anterior part of the sacrum only 8 inches.* The proportion of the spine thus grasped, as it were, by the iliac bones, which transmit the weight of the body upon the thigh-bones, corresponds with the mass which is to be sustained and moved; and the size and structure of the sacrum indicate, with those of the femur and tibia, the adaptation of the present great herbivorous Saurian for terrestrial life," p. 130.

I looked forward to the more detailed description, with illustrative figures, of this unique specimen, when further worked out, as being likely to form one of the chief

* The true anterior limit of the sacrum is defined by this admeasurement.

novelties, and most important additions, to be submitted to the members of the Palæontographical Society, and other cultivators of geology, in my forthcoming 'Monographs on the Fossil Reptilia of Great Britain,' of which the 'Reports' to the British Association, in 1840 and 1841, were the basis.

In some particulars I have been aided, and in a few illustrations anticipated, by the labours of zealous contemporaries. Two associated authors, taking advantage of the indications given in my 'Report,' obtained Mr. Saull's permission to examine the sacrum of the Iguanodon which I had discovered, and had a drawing taken of it, which they published in the 'Transactions of the Royal Society,'* confirming, in the main, my description, but describing an attached lumbar vertebra, as a sixth sacral one.

As the characters of the order *Dinosauria* were mainly founded on this specimen four plates have, in this 'Monograph,' been devoted to the illustration of its remarkable structure.

Tab. III gives a view of the under surface, of half the natural size in linear admeasurement.

The last of the lumbar series, L, upon the interspace between which and the first true sacral vertebra the neural arch of that vertebra, *n* 1, Tab. IV, has advanced, has thereby become confluent with the sacrum proper, characterised by the junction of its transverse processes with each other, and with the iliac bones. The confluent lumbar vertebra has a much broader centrum or body, , than that of the contiguous sacral vertebra, especially at its middle part, which presents a subquadrate transverse section, the sides being vertical, excavated near the neurapophysis, and meeting the under surface at a right angle: the under surface is convex transversely, especially at its middle part, concave longitudinally. The anterior articular surface is quadrate, with the angles rounded off, and is broader than it is deep: it is slightly convex vertically, flat transversely, except near the periphery, which is convex: some remains of its water-worn and mutilated neural arch, showing the normal relation of its piers to the centrum, and its partial anchylosis to the advanced neural arch of the first sacral vertebra, are shown at *n n*, fig. 1, Tab. VI: the antero-posterior extent of the piers is short; the neural interspace between them and those of the first sacral vertebra is wide.

The body of the first proper sacral vertebra, *s* 1, Tab. III, differs from the foregoing by its sudden decrease in transverse diameter, especially at its middle part, the sides being concave lengthwise, and with the under surface compressed and produced into a low ridge. In consequence of the advanced position of its neural arch, the first pair of sacral nerves pass over the upper surface of the centrum about one third from its hinder end, and deeply groove that surface in their passage; the fore part of the advanced arch of the succeeding vertebra rests upon and has coalesced with the expanded hinder end of the first sacral vertebra. The transverse processes of this

* 'Philosophical Transactions,' 1849, p. 275, pl. xxvi.

vertebra, which consist of short pleurapophyses, *pl* 1, have been advanced, like the neural arch, to the interspace between the first sacral and last lumbar vertebræ, and have coalesced with both; the major part of the expanded head of the short and strong sacral rib being fixed to the sides of the expanded anterior end of its own centrum: after becoming slightly constricted, the ribs expands, like the overlapping cervical ribs in the crocodile, in the direction of the axis of the body, but the sacral ribs more firmly unite their portion of the vertebral column together by becoming confluent at their expanded extremities. Almost the whole upper surface of the short sacral rib has coalesced with a strong, vertically developed, antero-posteriorly compressed, diapophysis, *d* 1, Tab. IV. These processes are continued outwards from the whole side of the neural arch, and form a series of strong transverse ridges, *d* 1—*d* 5, Tab. IV, progressively increasing in length to the fourth, *d* 4; the fifth, *d* 5, being of nearly the same length as the fourth. The neurapophyses extend forwards and backwards beyond the base of the diapophyses, and coalesce with each other and with the centrums, so as to convert the interneural outlets for the nerves into foramina. The neural spines, probably short in comparison with those in the dorsal region, and apparently more or less blended together to form a continuous ridge, have been broken or worn away to their bases, which are indicated by the letters *n* 1—*n* 5, in Tab. IV. The bodies of the second, *s* 2, Tab. III, and third, *s* 3, sacral vertebræ are compressed, and continue to present the carinate inferior surface; that of the fourth sacral *s* 4, and fifth sacral *s* 5, progressively expand, and are convex beneath. In the first to the fourth sacral, inclusive, the sides of the centrum present a rounded depression a little behind their middle, the neural arches of the second, third, and fourth sacral vertebræ rest two thirds upon their own centrum and one third upon that in advance, dipping wedgewise into the interspaces of the centrums as they cross from one to another: the neural arch of the fifth sacral, like that of the first, rests in a larger proportion upon its own centrum, above which its piers meet, leaving a triangular neural surface before and behind their junction. The posterior articular surface of the body of the last sacral vertebra is shown in Tab. VI, fig. 2, *s* 5; it is slightly concave; the upper surface of the centrum above this end, and for about one-fifth of its length, Tab. V, fig. 2, *s* 5, is free, the neural arch of the first caudal vertebra having resumed its normal position in regard to its centrum. The posterior zygapophyses, *z′ z′*, Tab. IV and Tab. VI, are in part preserved in the last sacral vertebra; the degree of diminution of the neural canal, as it extends, with partial expansions, through the sacral series, may be seen by comparing fig. 1 with fig. 2, in Tab. VI. The coalescence of the pleurapophyses and diapophyses circumscribes a series of four progressively expanding vertical canals on each side of the sacrum, the lower outlets of which are shown in Tab. III, and the upper ones, *o*, *o*, *o*, *o*, in Tab. IV: the nervous foramina, in the interspaces of the neural arches, open into these canals. There has been a tendency to ossification in the fascia extended between the upper borders of the strong boundaries of these foramina, of which the evidence remains, at *f*, Tab. III and IV, in a thick plate of bone, extending partly over the upper outlet of the second

foramen. The coalesced extremities of the fourth and fifth sacral ribs have been broken away on the left side. These coalesced extremities form a continuous tract of bone, *pl* 1′—*pl* 4′, Tab. III, with a flattened outer surface, slightly concave lengthwise, to which the iliac bone is attached, and has remained attached probably through partial confluence on the right side of the present specimen. The organic architecture of this part of the vertebral column of the ancient gigantic reptile cannot be sufficiently admired in reference to the due strength of the part thereby attained.

The pressure transmitted by the thigh bones upon the iliac bones is resisted, and is transferred by the strong vertical buttresses, formed by the modified and coalesced pleur- and di- apophyses, upon the bodies and neural arches of the sacral vertebræ; but, by the altered relative position of the neural arches and pleurapophyses, the weight transmitted by one pair of buttresses does not bear exclusively upon a single vertebral centrum, but is divided equally between two centrums. In the young and perhaps more active Iguanodon, prior to the general anchylosis that afterwards pervades this complex mass, the further advantage of a certain elastic yielding of the parts must have been gained, by the implantation of the piers of the neural arch, and the heads of the short, buttress-like ribs, upon or over the joints between the vertebral bodies. A like advantage is gained by the same modification, in regard to the position of the neural arches and ribs, in the vertebræ of the carapace of the Chelonian reptiles, and in the sacral vertebræ of the Ostrich; the structure of the latter is interestingly analogous to that of the same part of the spine in the extinct Iguanodon.*

A considerable proportion of the right iliac bone remains attached to the sacrum of the Iguanodon above described. It is a strong, elongated, subtriedral bone, firmly adherent by an inner flattened surface to the confluent expanded ends of the five sacral ribs, *pl* 1—*pl* 5. The outer surface is divided into two facets by a strong longitudinal ridge, for the attachment of some of the powerful muscles of the hind limb, and a second short, oblique, almost vertical, ridge, divides the bone into an anterior and a posterior portion. The anterior portion is again subdivided into a thick, strong, acetabular portion 62—62, forming the upper part of the cavity for the hip-joint, and a more slender portion extending forwards as far as the anchylosed lumbar vertebræ, and terminating in an obtuse point, 62′. The hinder portion of the ilium, 62″, is extended backwards beyond the surface of attachment to the sacral ribs, and probably terminated freely, as in most Lacertian reptiles; but the extremity of this part has been broken off.† The chord of the acetabular arc or concavity measures 8 inches. The major part of the acetabulum was contributed, as in most modern lizards, by the ischium and pubis. Upon the whole, the structure of the ilium accords more with the Lacertian than the Crocodilian type of the bone.

* See my 'Archetype of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27.

† In the Paper, 'Phil. Trans.,' 1849, by the authors who anticipated my illustrations of Mr. Saull's pelvis of the Iguanodon, I am stated, or at least the author of a 'Report on British Reptiles' is charged, p. 299, with having mistaken the anterior for the posterior part of the ilium. A reference to p. 135 of the

With the foregoing knowledge of the complex structure of the sacrum of the Iguanodon, the peculiarities of detached parts of those modified vertebræ become intelligible, and prove to be such as they were originally surmised to be.*

DETACHED BODIES OF THE SACRAL VERTEBRÆ OF THE IGUANODON, Tab. VII.

As such parts, especially the centrum or body, are not unfrequently found separated from the rest of the skeleton of immature individuals, it has appeared desirable to subjoin a description of the most common of these parts.

No. $\frac{127}{2127}$, Mantellian Collection, in the British Museum, is the centrum of a sacral vertebra of a sub-quadrate form, with a broad and flattened inferior surface, fig. 3, slightly concave lengthwise. The upper surface, fig. 4, is excavated by a wide and moderately deep canal, indicating the unusual size, for Reptiles, of the sacral portion of the spinal chord. The anterior, *n*, and posterior, *n'*, parts of the sides of this centrum, fig. 1, are raised, so as to form projecting sub-triangular rough articular surfaces, continued upon the margins of the neural canal, evidently for the attachment of the neurapophyses and the heads of the strong sacral ribs. The interspace of these anterior and posterior neurapophysial surfaces is formed by a smooth oblique groove, *o*, figs. 1, 4, connecting the smooth surface of the spinal canal with that of the free lateral surface of the vertebra, and indicating the place of exit of the sacral nerves: such outlet is necessarily in this unusual situation, because the holes of conjugation, as they exist in other vertebræ showing the ordinary position of neural arches, have here been obliterated by the impaction of the bases of the neurapophyses between the contiguous extremities of the bodies of the sacral vertebræ.

The anterior and posterior articular extremities of the present interesting fossil equally bespeak the peculiar character of the sacral vertebræ of the *Dinosauria*. They are impressed by coarse straight ridges and grooves radiating from near the upper part of the surface, fig. 2, like those on the corresponding part of a cetaceous vertebra when the epiphysial articular extremity is removed. These inequalities are here, doubtless, preparatory to that anchylosis by which the sacral vertebræ are compacted together in the mature Dinosaurs.

	In.	*Lines.*
The length of this vertebral body	2	10
The height	2	6
The breadth of anterior articular end	3	0
The breadth of middle part	2	2

volume of 'Reports of the British Association,' 8vo, 1842, will show how gratuitous such a statement is in regard to the 'Report on British Fossil Reptiles,' therein published. The posterior extremity of the ilium is there, as here, expressly described as the one which has been broken off; it is well displayed in the Maidstone Iguanodon.

* 'Report on Brit. Foss. Reptiles,' 1841, p. 130.

but articulate with two contiguous vertebræ, crossing, and being somewhat wedged into, the inferior interspace of those vertebræ; in two of the caudal vertebræ of the Maidstone Iguanodon, there are two closely approximated hæmapophysial surfaces, but in general the hæmal arch articulates with a single oblique triangular surface on each of the contiguous extremities of the co-articulated vertebræ; the hæmapophyses being here confluent at their vertebral as well as at their distal extremities.

A caudal vertebra exhibiting this modification, in Mr. Holmes's collection, measures, in the vertical diameter of the articular surface, 4 inches 9 lines; in its transverse diameter, 4 inches 6 lines; the breadth of the inferior surface of the vertebra is 3 inches 3 lines. The interspace between the anterior and posterior hæmapophysial surface is 9 lines; it is concave in the axis of the vertebra. The diameter of the spinal canal is reduced in this vertebra to 9 lines. The transverse processes are of very small size. The spinous process is broken off. We have seen that those of the sacral vertebræ appear to have been short. There is reason to think that the spinous processes increased in length for a certain distance as they receded from the sacrum, and then diminished. Thus, in a caudal vertebra (No. $\frac{130}{2130}$, Mantellian Collection, Brit. Mus.), evidently anterior in position, by its size, by its oblique processes, and by the place of development of its transverse processes from the base of the neural arch, the spinous process is 5 inches in height, while in the six caudal vertebræ preserved in natural sequence and relative position in the Mantellian Collection, the spines are more than double that height, Tab. VIII. That the vertebra (No. 2130) is not a more posterior caudal vertebra from a larger Iguanodon is shown by the relative thickness, as well as position, of its transverse processes, as compared with the six caudal vertebræ above mentioned, for their transverse processes sensibly diminish in every diameter, and especially in vertical thickness, from the first to the sixth; and, moreover, it is evident that, in this short series, the spines decrease in height both forwards from the third, as well as backwards, but more so in the latter direction. Thus the spine, *ns*, of the first of these vertebræ is 14 inches high, of the third 15 inches, and of the sixth 13 inches. These spines increase in breadth toward their summits, which are truncated, and in contact with each other, partly from this expansion, partly from the posterior ones being slightly bent forwards. One cannot witness this change of character in so short a segment of the tail without a conviction that this appendage must have been relatively shorter than in the Iguana.

The first spine, besides being somewhat shorter, is more rounded off at its anterior margin than the third, a difference which is still more obvious in the detached caudal (No. 2130) above described; but above its origin a thin trenchant plate is extended for a short distance from the middle of the anterior margin: this character, which calls to mind one that is present in a greater proportion of the vertebral column in the Crocodilians, is more strongly developed in the second and third vertebræ. The neurapophysial suture is more nearly obliterated in the sixth than in the first of this

arch *n*; the base of this arch equals about two thirds of the antero-posterior extent of the centrum to which it is attached, a little nearer the anterior than the posterior end. The arch sends forwards a pair of long zygapophyses, *z*, whose articular surfaces look inwards and a little upwards; a low ridge traverses two thirds of the summit of the arch, fig. 2, from the hinder third of which springs the neural spine, *n s*, which slightly gains in antero-posterior extent as it rises: but its summit is broken away: the posterior zygapophyses *z*, fig. 1, project from the back part of the base of the spine: their articular surfaces look outwards and a little downwards.

The figure 2, of the vertebra, viewed from above, shows the form and extent of the summit of the neural arch, which is rarely preserved in fossil vertebræ. Fig. 3 shows the anterior, and fig. 4 the posterior, surface of the vertebræ; the articular ends of the centrum are very slightly and irregularly concave, with the margin thickened and rounded off. The under surface of the centrum, fig. 5, is characterised by a median groove or channel between two parallel ridges which extend from the anterior *h* to the posterior *h'* hæmapophysial surfaces. Of these the posterior one is the largest.

The neural canal, figs. 3 and 4, *n*, is contracted; its area is a full transverse oval.

With respect to the terminal caudal vertebræ in which diapophyses and hæmapophyses have ceased to be developed, no specimen of Iguanodon has yet been discovered in which any such vertebræ have been so associated with the rest of the skeleton as to enable the conscientious observer to determine their character as unequivocally belonging to the Iguanodon. Two vertebræ, from the Wealden, near Battle, in the Museum of the Royal College of Surgeons, in which the diapophysis has subsided to a longitudinal ridge, crossing the upper third of the centrum in the smaller specimen, have been described in the 'Catalogue' as probably belonging to the Iguanodon; for it is most probable that the typical form of the body of the Iguanodon's vertebræ is modified or lost in such terminal and rudimental vertebræ; but as these are, in every case, the least characteristic bones of an extinct animal, their loss is of the least consequence, and any positive affirmation regarding them, on imperfect evidence, becomes the more gratuitous.

Skull of the Iguanodon.

Tympanic Bone. Tab. X.

Of the bones of the head of the Iguanodon, the characteristic one above named, a fragment of the upper jaw, and a larger proportion of the under jaw have been brought to light: the portions of the jaws, at least, are demonstrably those of the present species of herbivorous reptile, by the teeth which they contain: the great Cetiosaur and Streptospondyl may possibly have afforded the specimen figured in Tab. X, which, in

there is no appearance of a sutural attachment in its longitudinal extent, with a parallel and co-extensive squamosal bone, as in the Crocodilia: the points of connection seem to have been restricted to the two expanded extremities.

LOWER JAW OF THE IGUANODON. Tabs. XI, XII, XIII.

At the beginning of the year 1848, Mr. George B. Holmes, of Horsham, obtained from the Stammerham stone-pit, or quarry, of Wealden, near that town, the right ramus of the lower jaw of a young Iguanodon, which is figured of the natural size in Plates XI and XII.

The accurate and beautiful drawings made by his daughter, Miss G. M. Holmes, from which these plates are engraved, were most liberally transmitted to me, at that time, for description. Learning, however, from Dr. Mantell, when I was about to communicate that description to the Geological Society, that he also had just received from Captain Brickenden, of Warminglid, Sussex, the lower jaw of a larger Iguanodon, which he was desirous to describe for the Royal Society of London, I declined to use the materials with which Mr. Holmes had favoured me, until Dr. Mantell's observations had appeared. His Memoir was accordingly published in the 'Philosophical Transactions,' Part II, 1848.

The most remarkable conclusion to which the author of that Memoir arrived, after a study of the above materials, was, that the Iguanodon had been endowed, not only with fleshy or muscular lips,* hitherto believed to be the peculiar characteristic of the mammalian class amongst air-breathing vertebrate animals, but with such lips greatly developed.†

The correlation or association of such muscular and sensitive appendages to the jaws with the necessity of deriving lacteal nourishment by the act of suction, during the infancy of the animal, has hitherto been so constant and exclusive in the air-breathing vertebrates, that a transition from the Reptilian to the Mammalian class, by the conjunction of fleshy lips with a scaly skin and cold blood, would be a most unexpected and extreme exception to one of the best established generalizations in Comparative Anatomy.

I shall, first, give a description of the portion of jaw from Stammerham, then compare it with the larger jaw obtained from Tilgate Forest, and finally endeavour to

* "The great size and number of the vascular foramina, &c., indicate the great development of the integuments and soft parts with which the lower jaw was invested." p. 197.

† "The sharp ridge bordering the deep groove of the symphysis, in which there are also several foramina, evidently gave attachment to the muscles and integuments of the under lip; and there are strong reasons for supposing that the latter was greatly produced, and capable of being protruded and retracted, so as to constitute, in conjunction with a large fleshy prehensile tongue, a powerful instrument," &c., p. 197. The author proceeds to infer from "the edentulous and prolonged symphysis, and the great development of the lower lip and the integuments of the jaws, as indicated by the number of vascular foramina, a striking analogy to the edentata." Ib., p. 198.

Eighteen alveolar fossæ for the lodgement of the contracted sub-cylindrical bases of the teeth are exhibited in Mr. Holmes's specimen; but all the teeth that were fully developed and had occupied those semi-cylindrical depressions have been lost. Greater or less portions of the protruding summits of six successional teeth are seen below the alveolar grooves of the old teeth, and of so much larger size as indicates a more rapid growth of the young Iguanodon, than in modern reptiles. In the different proportions in which the young teeth are developed, may be discerned an illustration of the same law of preservation of an adequate proportion of an ever changing series of masticatory organs, which is illustrated by the condition of the dental series in many modern reptiles and fishes. The teeth marked *k, k, k,* for example, of which the summits of the crown have but just begun to be calcified, alternate with those marked *l, l, l,* fig. 2, Tab. XI, in which the crowns are more advanced. One may see by the size of these teeth that they are destined for work in a larger jaw than that of the young Iguanodon in which they are cradled; one may likewise discern the unfitness of the actual alveolar grooves for the reception and retention of the large successional teeth, and thence rightly infer that the bone grows and goes with the growth and disappearance of the teeth themselves; the alveoli of the shed teeth being progressively absorbed as the osseous bed of the new teeth rises along with them. The same concomitant growth of the jaw-bone and the teeth has long been recognised in the mammalian class, and is strikingly exemplified in the elephant, in which the large complex molars succeed each other from behind forwards.

The surface of the jaw below the alveolar groove is smooth, but is traversed by a deeper and narrower groove continued from the entry of the mandibular canal, *i*, forwards just above, and nearly parallel with, the lower border of the ramus, becoming shallower and descending to that border as the groove, *d*, approaches the symphysis, *s*; the major part of this groove was probably covered by the splenial element, (opercular of Cuvier), in the entire ramus of the Iguanodon's jaw. Above the groove the inner surface of the dentary is slightly convex at its posterior half, and slightly concave at the anterior half. The edentulous, narrow, sloping margin of the jaw, *b, e*, has a slightly tumid roughness along its inner side, as if for the firm attachment of a callous covering in the recent animal. The actual symphysis of the jaw is about two thirds of an inch in extent, and a quarter of an inch in greatest depth, almost horizontal in position, but bent, with the concavity looking upwards; the inferior and anterior angle of the jaw, *d*, projects a little way beyond the fore part of the symphysis, and the back part of the symphysis is impressed with a longitudinal groove, fig. 2, *s*, parallel with, but above, the anterior end of the mandibular groove, *d*.

In the small extent of the mandibular symphysis the Iguanodon resembles the *Lacertilia*, and differs from the *Crocodilia*, even from the true crocodiles and alligators in which the symphysis is much less than in the gavials; but the position of the symphysis at the lower end of the anterior termination of the ramùs, and the sloping

more numerous than in the younger jaw, but are arranged, as in that jaw, along the outside of the alveolar wall, beginning near the base of the coronoid process, and extending down the edentulous sloping part of the jaw; their size is exaggerated in the figure given in the 'Philosophical Transactions,' and there is no particular anterior foramen, larger than the rest, and meriting, as in the mammalia, the name of "foramen mentale." The exterior marginal groove of the edentulous border is better marked in Capt. Brickenden's than in Mr. Holmes's specimen, but the alveolar wall has suffered more injury in the Tilgate specimen than in that from Stammerham; in the latter, indeed, it seems to be entire, and so much of the thin inner border is preserved as to show that there was not any internal alveolar wall co-extensive with the outer one. I cannot discern evidence of more than 18 dental depressions on the outer alveolar wall of the large lower jaw from Tilgate; the number, therefore, is the same as in the specimen from the younger Iguanodon, just as we find the same number of teeth in the same species of Crocodile at all ages of the individual, no additional teeth being added to the series from behind, like the true molars in the Mammalia, in the course of the change of dentition as the animal advances to maturity. So much of the inner surface of the dentary bone as is preserved entire in the Tilgate specimen, corresponds with the same portion in the younger specimen from Stammerham; no part is absolutely flattened: the part sustaining the upper division of the mandibular canal has been broken away.

If we pass now to the consideration of the inferences as to the nature of the soft or perishable teguments of the jaw, which are deducible from the characters of the bone itself, it may be first remarked, that the disposition of the vessels and nerves, supplying such teguments, differs according to their nature in different existing air-breathing vertebrate animals, and the jaw-bone exhibits corresponding differences in relation to such modifications of the mandibular vessels and nerves. To those who may not have ready access to Cabinets of Comparative Osteology, a glance at the plates of the well-known and widely distributed 'Ossemens Fossiles,' of Baron Cuvier, will show that the rami of the lower jaw in Mammalia usually present one large, rarely two or three, foramina, on the outside of each ramus at its fore-part; but that, in reptiles, as may be seen in the Crocodiles, Pl. 1; the Lizards, Pl. 16; the Tortoises, Pl. 11;* the nervo-vascular foramina are more numerous, smaller, and arranged, in a more or less linear series along nearly the whole extent of the outside of the ramus of the jaw.

The first modification relates to the concentration of the nervous and vascular influences upon thick, muscular, soft, sensitive, extensile and retractile lips, covering the jaws, and extending beyond their fore part, where such lips are most developed. The second modification relates to a more diffused and equable supply of the nervous and vascular, but especially the latter, influences, to salivary follicles opening along the

* The 4th edition, 1824, tom. v, pt. ii, is here cited.

the Iguanodon in Pl. XVII, fig. 4, of the memoir above quoted in the 'Philosophica Transactions' for 1848, the nervo-vascular foramina are not diminished in the same proportion as the jaw itself: they are accurately delineated both as to number and size, in Tab. XIII, fig. 1, *g*, *g*, of the present Monograph. The angle, also, at which the two rami of the lower jaw are conjecturally united in Pl. XVII, 'Phil. Trans.,' 1848, is much too acute; and the restoration of the lower jaw in the Mantellian collection, British Museum, accordingly leaves a transverse space equalling little more than one half the breadth of the upper jaw, to the description of which I next proceed.

Fragment of the Upper Jaw of the Iguanodon. Tab. XIII, figs. 2, 3, 4.

After the tympanic bone and lower jaw, the most instructive and intelligible part of the skull of the Iguanodon, as yet obtained, is a portion of the upper jaw, consisting of so much of the back part of the left superior maxillary bone, with the alveolar groove, as includes ten dental recesses, seven of which contain teeth. This specimen was washed out of the submerged Wealden deposits off Brook Point, Isle of Wight, and is now in the British Museum.

The alveolar groove opens widely and obliquely upon the inner and under aspect of the fragment, *a*, *a*, fig. 3: the outer side or parapet, fig. 2, is formed by the chief osseous mass with the outer compact wall of the jaw, fig. 4, *b*, *b*; this wall sends off from its upper and outer side a process, *m*, directed backwards and a little outwards, with the end broken and blunted by attrition, or water-worn; the bone is then continued backwards, slightly expanding in the vertical direction, and terminating in a point, *p*, also obtusely rounded by attrition subsequent to fossilization. Both this extremity and the malar process show unequivocal evidence of sutural surfaces upon their outer and upper side; that upon the malar process is oblong and depressed; that upon the upper and outer part of the hinder end of the maxillary is broad, oblique, and divided into two parts by a longitudinal elevation. Between this extremity and the malar process the canal, *c*, for the nerves and vessels of the upper jaw enters the substance of the bone, immediately above the deep rounded groove that divides the process from the body of the bone; a fossa is continued forwards above the canal, for an inch and a half, in advance of the entry of the canal, and continues the separation of the process from the body of the bone in that direction.

The smaller anterior end of this fragment is of a trihedral figure; the inner and under side is formed by the dental groove, the inner and upper side is flat; the outer side is slightly convex. At the angle where the last two sides meet there is a narrow sutural or fractured surface continued forwards from the sutural depression upon the upper part of the malar process. A transverse section of the anterior extremity of the fragment, fig. 4, taken through the foremost tooth, 1, and its successor, 2, shows com-

a thin layer of dentine has been formed beneath the enamel; the mineral matter now occupies the place of the original vascular pulp of the dental matrix. The flattened side of the crown of this tooth is turned towards the outer alveolar wall, the convex surface looks inwards and downwards; in the lower jaw the teeth, Tab. XI, fig. 2, *l*, *l*, have the reverse direction, as stated in Dr. Mantell's Memoir on the lower jaw, from Tilgate.* Next, behind the young tooth, 2, is the recess from which an old tooth has been expelled; and behind the recess is a fully formed crown of a tooth, 3, with the beginning of the fang, which tooth had come into use, but its grinding surface has been worn down by the rolling of the fragment after fossilization and extrication of the specimen from the matrix; a narrow recess follows this tooth, and then comes the fang and base of the crown of an old tooth, 4, partly undermined, and about to be pushed out by the crown of a successor, 5; next follows an empty recess; then the base of apparently a fully developed tooth, 6, the projecting crown of which has been broken away; close behind this tooth is the base of a narrower and smaller tooth, 7, followed by the recess for a similar sized tooth, which terminates the series.

We thus see that, as in the lower jaw of the Iguanodon and in the upper jaw of the Iguana and Tejus, the teeth decrease in size at the hinder end of the series; and that this end of the series in the Iguanodon inclines outwards, as does the same end of the alveolar series in the lower jaw, to which it was opposed.

As a similar portion of bone, recognised by Dr. Mantell as a "fragment of the upper jaw of an Iguanodon," when first discovered in 1838, in a quarry near Cuckfield, has been referred to the opposite end of the jaw, in the Memoir in which it is figured, 'Philosophical Transactions,' 1848, Pl. XIX, pp. 190, 191, with an appeal to the osteology of the recent Iguana, as confirmatory of that determination, I may be excused for concluding by a summary of the facts which seem to me to determine rightly the nature and relative position to the rest of the skull of the present very interesting part of the fossilized skeleton of the Iguanodon. The size of the teeth forbids the supposition that the fragment in question can have formed part of a pterygoid or palatine bone,—such a dentigerous bone, viz., as is shown in the skull of the Mosasaurus and, amongst existing Saurians, in the Iguana: both the shape of the pterygoid and the relative size of the teeth discourage the idea that the present fragment can be part of the homologous bone: it would be contrary to all known analogies to refer it to the palatine bone; and there remains, therefore, only the superior maxillary bone with which to compare it. Of this bone the specimen is evidently that part or extremity containing a natural termination of the alveolar groove; this is shown by the suddenly diminished size of the teeth and alveoli, and by the portion of bone, *p*, fig. 2, which is continued beyond the last alveolus.

The question next arises:—Does the fragment include the anterior or posterior end of the alveolar groove? In answer to this I may first remark, that the outer and inner

* Philos. Trans., 1848, p. 187.

sides of the fragment are determined by the relative depth of the walls of the alveolar groove, and by the relative position of the new and old teeth. In no pleurodont lizard is the deeper wall the innermost; and in no lizard or crocodile does the germ of a successional tooth appear on the outside of the base of the one it is about to succeed. The philosophy of Zootomy compels one to be guided by so great a number of observed instances, as is implied by the above generalized statement, as by a rule; and we know that the lower jaw of the Iguanodon conforms to that rule, by direct observation. In the upper jaw of the Iguanodon the successional tooth-germ is not situated directly on the inner side, but is also behind the tooth about to be displaced, at least in most of the specimens in the present fragment.

The extremity of the alveolar series, therefore, exhibited in the present fragment, must be either the fore end of the right maxillary bone or the back end of the left maxillary bone. The expansion and bifurcation of the bone, as it approaches towards the end of the alveolar series, are opposed to every analogy presented by the fore part of the maxillary in the Lacertian and Crocodilian reptiles. The foramina, grooves, and sutural surfaces become utterly unintelligible in this supposition; which is opposed, moreover, by the direction of the nervo-vascular outlets on the outer side of the bone, and by the curvature of the extremity of the alveolar series, as compared with the anterior extremity of that series in the lower jaw. In favour of the conclusion that the fragment in question is from the back part of the upper jaw, the expansion of the bone as it recedes from the triedral fractured end, *a*, *a'*, the direction of the nervo-vascular outlets, *g*, *g*, the altered direction of the alveolar groove, inclining, *e. g.*, outwards to be adapted to the hinder curve of the alveolar groove of the lower jaw, and the diminished proportions of the teeth at its obvious termination, all concur. And I may add that, supposing the Iguanodon, like the Iguana, to have had the dental series of the upper jaw prolonged forwards upon a premaxillary bone, the alveolar series of the maxillary would have been continued nearer to the end of the bone, and would have terminated more abruptly than it does in the present fragment.

Thus conducted to the conclusion that we have in the fragment in question the hinder part of the left superior maxillary bone, we have evidence that the Iguanodon differed (as, indeed, from the important differences in other parts of the skeleton might have been expected) from the Iguana and the Crocodiles, in having the alveolar end of the upper jaw produced backwards, beyond that outstanding backwardly inclined process, which gave attachment to the malar bone, such backwardly produced dentary end of the bone corresponding with that end, in the existing reptiles above cited, which articulates with the ectopterygoid ("os transverse" of Cuvier).

The dental series, thus brought more beneath the cranial part of the skull, would be more favorably placed for the operations of the masticatory muscles inserted into the lower jaw, and the backward prolongation of the dentary element, where it is developed into a coronoid process, is a departure from the ordinary reptilian structure

of the lower jaw, in itself significant of some correlative modification of the upper jaw. So far as the valuable fragment in question illustrates the nature of that modification, we discern in it an approximation to the mammalian type of the superior maxillary bone, subservient probably to a greater development of the homologue of the masseter muscle than is found in any recent reptile.

As the lower jaw of the *Iguanodon* does not contain more than 18 teeth in each ramus, it may be concluded that the portion of the upper jaw above described, supported at least one half of the dental series of the left side. The total length of that series in the skull to which such portion of jaw belonged must have been about 16 inches. The length of the alveolar tract, in the largest example of a ramus of the lower jaw yet discovered, Tab. XIII, fig. 1, is 13 inches.

In a cranium of the *Iguana tuberculata*, which measures $2\frac{1}{2}$ inches in length, the dental series occupies four sevenths of that length: according to the same proportions, therefore, the cranium of the Iguanodon, affording the above fragment of the upper jaw, would be 2 feet 4 inches in length. If the lower jaw of the Iguanodon exceeded the length of the cranium in the same proportion as in the Iguana, 2 feet 8 inches may be assigned to the total length of the skull of the Iguanodon, according to the evidences as yet obtained. But the unbiassed will feel that the rest of the structure of the Iguanodon, and especially of its teeth and vertebral column, differs in too great and important a degree from that of the Iguana to allow much confidence to be attached to the conclusions formed or suggested as to the Iguanodon, according to the osteology of the recent lizard, after which it has been called.

TEETH OF THE IGUANA. Tab. XVIII. (Figs. 1—5, after Mantell, 'Phil. Trans.')

Respecting these characteristic parts of the great extinct Reptile, little need be added to the observations recorded in my 'Odontography,' in the 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' pp. 115—118, and the excellent descriptions by Drs. Mantell and Melville, in the 'Philosophical Transactions,' for 1848.

Fig. 1, is a fully formed and moderately worn tooth of the upper jaw, showing the outer side; *a*, is the submedian primary longitudinal ridge, *b*, *b*, the accessory ridges, *c*, *c*, the lamello-serrated margins of the crown, of which the anterior is the longest; *d*, *d*, the compressed subquadrate fang. Fig. 1 *a*, gives a view of the fore part of the same tooth, showing the varying proportions of the two diameters of the crown and fang. Fig. 1 *b*, gives the form of the grinding surface of the crown; *a*, is the primary ridge on the enamelled side; *b* and *c*, the two facets produced by the attrition of two opposed teeth on the lower jaw.

Fig. 2. The outer side of an old tooth from the left upper maxillary bone, of

Bones of the Extremities of the Iguanodon.

These are remarkable for their superior development in proportion to the vertebræ of the trunk, as compared with the Iguana, the Crocodiles, and other existing Sauria. The scapular arch accords with the Lacertian type in being complicated with clavicles, and in the great breadth of the coracoid; but the scapula, in its length and simplicity, resembles more that of the Crocodiles than of the Lizards.

Scapula, Coracoid, and Humerus. Tab. XIV. One third the nat. size.

The scapula, Pl. XIV, figs. 1 and 2, is a long, flat, narrow bone, slightly bent backwards, gradually contracting in breadth and augmenting in thickness from its free extremity, answering to the base, *a*, to its articulated end, *d*, which suddenly expands and developes processes, *b*, *c*, before joining the coracoid, *f*.

These processes are two in number; one, *b*, is from the anterior border a little above the surface, *d*, for articulation with the coracoid; it is short and obtuse: the other, *e*, is still shorter, and comes off from the posterior border just above the articular surface, *c*, for the head of the humerus. The outer surface of the bone is slightly depressed between these processes, and becomes contracted beneath them where it forms the two articular surfaces, *d*, *c*, above mentioned.

The process, *b*, answers to the stronger and broader anterior process of the scapula of the Crocodile: the posterior process, *c*, seems to have no homologue in the modern Reptilia.

The scapula in the Amboina lizard, called *Istiurus*, sends backwards and upwards a process, but it is relatively longer than in the Iguanodon, and comes off higher up the scapula: the Psammosaurus and Grammatophora have no such process, and the entire scapula is much broader in proportion to its length. The scapula of the Iguanodon in general shape resembles that of the Crocodilia more than that of the Lacertian, but it is longer and more slender than in the Crocodile. The scapula, seen fractured across the femur in the Maidstone Iguanodon, see Tab. XXXIV, 'Monogr. Cretaceous Reptiles,' and figured in Dr. Mantell's Memoir, 'Phil. Trans.,' 1841, Pl. VIII, fig. 30, as an undetermined bone, repeats all the essential characters of the scapula so beautifully exposed, in natural connexion with the coracoid, in Mr. Holmes's specimen, figured in Tab. XIV, fig. 1.

The coracoid, fig. 2, *f*, more closely accords with the Lacertian type of that bone: it is a sub-semioval plate, broader than it is long, with the middle of its straighter border produced and thickened, and divided into two articular facets; one, fig. 1, *f*, for the scapula, the other, *g*, for the humerus: this articular part or "head" of the coracoid is marked off by a short constriction or "neck" from the broad plate or

the "head," widens as it sinks, its dilated termination answering to a foramen at that part of the coracoid in the Iguana, Istiurus, and Grammatophora: a smooth rounded notch divides the back part of the head from the backwardly produced obtuse angle of the bone, fig. 2, *g*. There is no process extended forwards from the fore part of the "body" of the bone: a notch, fig. 1, *h*, which penetrates the bone at the fore part of scapular end of the bone, as in the Lacertians above named; the lower and inner border of the expanded body of the coracoid describes a full semi-oval contour, which, in Mr. Holmes's specimen, fig. 2, is broken by a short and narrow notch, entering about the middle of that border.

In the comparative simplicity of the coracoid of the Iguanodon we may discern an affinity to the Crocodilian reptiles, and in its degree of expansion an affinity to the Lacertian order: this bone, as well as some other part of the skeleton, manifesting the intermediate position of the herbivorous Dinosaur, and its adherence to a more general type of Reptilian organization, than the modern forms of Reptile present.

An articular portion of the coracoid, measuring 10 inches in diameter, and discovered in the Wealden of Tilgate forest, is preserved in the British Museum.

The chief mark of difference from the Crocodilian structure of the scapular arch, and of resemblance to the Lacertian type, is the presence of a distinct pair of clavicles, the form of which is well shown in the instructive collection of parts of the same skeleton of the Iguana, discovered by Mr. Benstead, in his Green Sand quarry, near Maidstone. The only other bones to which the long and slender ones, marked "clavicle," in Tab. XXXIV, 'Mon. Cret. Reptiles,' can be compared, are the thoracic ribs and the fibulæ. The presence of the fibula in the same block of stone, and its discovery in close proximity with the tibia and femur in the Wealden strata, satisfactorily prove that the present remarkable bone cannot have formed part of the hinder extremity. And since, in most recent lizards, the radius, which is the more slender of the two bones of the fore-arm, differs from the fibula in little more than in being somewhat shorter and thicker, there is still less reason for supposing the bone in question to have belonged to the fore arm.

The form of the ribs of the *Iguanodon* is well known; their characteristic proximal extremity, in the longer anterior pairs of thoracic ribs, is shown in Tab. II, and they become shorter and more curved as they advance from the middle to the anterior part of the chest.

Amongst the bones obtained by Dr. Mantell from the quarry-men of Tilgate forest, and submitted by him, in 1830, to the examination of Baron Cuvier, was one, 28 inches in length, now in the British Museum, which the great founder of Palæontology thought "might be a clavicle:"* portions of other homologous bones have been found, indi-

* This opinion is cited by Dr. Mantell in his 'Geology of the South-East of England,' 8vo, 1833 p. 308.

A massive fragment of a broad osseous plate, bearing a segment of a large articular cavity at its thickest margin, and thence extended as a thinner plate, bent with a bold curvature, and terminated by a thick rounded labrum, offers characters of the Lacertian type of the pubis too obvious to be mistaken. This specimen, now in the British Museum, (No. $\frac{187}{2187}$, Mantellian Catalogue), is from the Tilgate strata; and since the modifications of the ilium of the Iguanodon in the Maidstone skeleton approximate to the Lacertian type of the bone, and especially as manifested by the great *Varani* in which the recurved character of the pubic plate is most strongly marked, we may, with much probability, assign the fossil in question to the pelvis of the Iguanodon.

This fine portion of pubis is of an inequilateral triangular form, 16 inches in its longest diameter, 9 inches 6 lines across its base or broadest part, 6 inches 8 lines across its narrowest part. The fractured surface of the bone, near the acetabulum, is 3 inches 3 lines thick. The acetabular depression is 7 inches across, a proportion which corresponds well with the size of the cavity in which the head of the Iguanodon's femur must have been received. One angle of the cavity, corresponding with the anterior one in the *Varanus*, is raised; a broad and low obtuse ridge bounds the rest of the free margin of the cavity. The smooth labrum exchanges its character near one of the fractured edges of the bone for a rough surface, which indicates the commencement of the symphysis. In the apparent absence of the perforation below the acetabular depression, the present bone agrees with the crocodilian type.

Ischium.—A second fragment of a large lamelliform bone, also in the British Museum, (No. $\frac{188}{2188}$, Mantellian Catalogue), presents, in its general form and slightly twisted character, most resemblance to the ischium, with traceable modifications intermediate to those presented by the extinct *Goniopholis* and the modern *Varani* and *Iguanæ*. The loss of the acetabular extremity, which is broken away, prevents a certain determination of this bone; the only natural dimension that can be taken is the circumference of the neck, or contracted portion between the acetabular end and the expanded symphysial plate: this circumference gives 7 inches. The slight twist of the bone upon this part as it expands to form the broad symphysial plate,—a character which is well marked in the ischium of the *Goniopholis*,—gives it a superficial resemblance to the humerus of some large Mammalia; but the bone is too short in proportion to the breadth indicated by the fractured symphysial end, to afford any probability of its having been a humerus of a land reptile, and much less of the Iguanodon, in which the form of the humerus is now well ascertained.

FEMUR OF THE IGUANODON. Tab. XV, figs. 1, 1*a* and 1*b*. One fourth the nat. size.

Several specimens of this remarkable bone,—the one that most impresses the observer with the magnitude of the extinct reptile to which it belonged,—are preserved in the British Museum. Of these the most entire and perfect specimen, the subject of the above plate

proximal end of the bone, a longitudinal column, the top of which may be compared to a trochanter, is separated by a deep and narrow vertical groove or fissure, from the main shaft of the bone, and falls into that shaf a little lower down: here the shaft expands and becomes rather flattened from before backwards, but is sub-quadrangular: a low ridge, produced by the union of two broad and flat surfaces, extends down the middle of the anterior surface of the shaft, and, inclining towards the inner condyle, gradually disappears. A little below the middle of the shaft the inner margin is produced into the angular ridge or low and long process, above described (*d*, fig. 1). The shaft of the bone has a large medullary cavity. The distal end is characterised by a deep and narrow anterior longitudinal groove, situated not quite in the middle, but nearer the external condyle; there is a corresponding deep longitudinal groove on the posterior part of the distal end, which is wider than the anterior one, and in the middle of the bone, separating the two condyles, but inclining beneath, and as it were undermining the backward projecting part of the internal condyle; this is much more prominent than the external one, which is traversed or divided by a narrow longitudinal fissure. The articular surface is irregular and tuberculate.

The following are some of the dimensions of this femur:

	In.	*Lin.*
The lateral diameter of proximal end	2	8
The lateral diameter of distal end	3	0
Antero-posterior diameter of outer part of proximal end . .	2	0
Antero-posterior diameter of outer part of internal condyle . .	2	3

In five separate long bones, in the Mantellian Collection, having the general characters of the two bones above described and of those of the Maidstone Iguanodon, which are marked "femur" in Tab. XXXIV, 'Monograph of Cretaceous Reptiles,' Nos. 1 and 3 differ from Nos. 4 and 5 in the greater inward production of the head, making the concavity of the line descending from the head to the median internal ridge somewhat deeper. The lower angle of this median ridge is more produced in Nos. 1, 2 and 3, than in Nos. 4 and 5. The whole inner contour is more regularly concave in No. 5 than in Nos. 1 or 3. Of these five bones, No. 2 was found associated with a tibia and fibula; and the differences above indicated illustrate the extent of the individual varieties of the same bone, so far as my opportunities of comparison have extended.

The femur of the Iguana differs as widely from that of the Iguanodon as does that of the Monitor or any other Lacertian reptile. The forms of the head and trochanter of the femur of the Iguana are just the reverse of those in the Iguanodon. The head of the femur in the Iguana is flattened from side to side, and its upper convex surface is extended from before backwards, making no projection over the gentle concave line leading from its inner surface down to the inner condyle. In the Iguanodon the head is rounded and rather compressed from before backwards, and is produced, as in Mammals, over the inner side of the shaft.

The fibula nearly equals the length of the tibia; the well-preserved specimen figured in Tab. XV., figs. 4—7, forms part of Mr. Holmes's choice collection of Wealden Remains from the vicinity of Horsham: it has belonged to a younger individual Iguanodon than the femur and tibia figured in the same plate.

The tibia of the Iguanodon equals the united length of nine of the dorsal vertebræ, while in the Iguana it does not exceed the united length of five dorsal vertebræ, although it more nearly equals the femur in length than in the Iguanodon. The head of the tibia is more expanded and more complicated by the condyloid prominences, and by their deep and wide groove in the Iguanodon than in the Iguana.

The disparity of strength between the tibia and fibula is considerable, but the difference in the thickness of the lower extremities of the two bones is less than the proportions of the shaft would indicate. On the middle of one of the flat sides of the fibula is an oblong rough surface slightly raised, measuring 3 inches by 2 inches. The articular extremities of the fibula are tuberculate, the lower and larger end is 5 inches across, the smaller one 3 inches across.

The fibula is more expanded towards the distal end and more flattened against the tibia in the Iguanodon than in the Iguana. It differs, also, from that of the Iguana in the well-marked, shallow, longitudinal concavity along the side of the lower half of the shaft which is next the tibia, as is shown in Tab. XV, fig. 4, (the views of the fibula in this plate have unfortunately been drawn on the stone upside down). The opposite side of the shaft is smooth and convex, as shown in fig. 3. In one diameter the fibula gradually contracts from the proximal to the distal end, as is shown in fig. 5; but in the opposite diameter it expands in a greater degree, and very suddenly, at the articular distal end. The form of the proximal surface is shown at fig. 7, that of the distal one at fig. 6.

The unusually perfect specimen, from which the figures 3-7 were taken, was obtained from the Wealden formation at the Tower-hill pit or quarry, near Horsham, by my esteemed friend G. B. Holmes, Esq., of that town, by whose accomplished daughter the original drawings of the bone were made. Another fibula of a small Iguanodon from a pit at Rusper, in the same gentleman's collection, equals the antero-posterior extent of the spines of eight dorsal vertebræ of the same individual. This bone is 13 inches long, 6 lines across the proximal end, and two inches across the distal end.

Metatarsal and Phalangeal Bones of the Iguanodon. Tabs. XVI and XVII. Nat. size.

Of the great Iguanodon from the Horsham quarry, two metacarpal or metatarsal bones are preserved in natural juxtaposition, in Mr. Holmes's Museum: one exceeds the other by four inches in length, and measures 2 feet 6 inches: the breadth of its distal end is 3 inches 3 lines; the shaft is compressed and subtrihedral; its texture is

length, and 13 inches in circumference at the largest tarsal extremity. The colossal proportions of a fragment of a femur in his possession, from Tilgate Forest (Pl. 18, fig. 1 of the same work), which measures 23 inches in circumference in the smallest part, sufficiently accord with those of his metatarsal bone last mentioned, as well as our metacarpal bone from the same formation in the Isle of Wight, and give strong probability to the opinion that all these three fragments of the skeleton of a reptile of such extraordinary stature may be referred to the Iguanodon. It is obvious that these supposed metacarpal and metatarsal bones are much shorter and thicker in their proportions than the metacarpal or metatarsal bones of any living lizards or crocodiles; but when we consider the enormous weight which the foot of an animal whose femur was 23 inches in circumference must have sustained, a reduction of length and increase of bulk in the bones which supported such a colossal frame, must have been attended with many mechanical advantages."

The distal or ungual phalanges of the Iguanodon, although doubtless offering certain modifications of form in different toes, are shown by those preserved in the Maidstone Iguanodon, and by others of much larger dimensions found associated with the bones of the great Iguanodon of the Horsham quarry, to have had a less incurved, broader, and more depressed form than in other known saurians. Two of the largest ungual phalanges of the Horsham Iguanodon in Mr. Holmes's collection, are broad, subdepressed, and exhibit, as in most other saurians, the curved vascular groove on each side: they have an articular, slightly concave base, and terminate anteriorly in a round blunt edge; the outer boundary of the lateral grooves form at the posterior end of the groove, a laterally projecting process, making this part of the phalanx broader than the articular extremity or basis. The following are dimensions of the largest of the two phalanges:

	In.	*Lines.*
Length	5	4
Breadth	3	2
Breadth at articular end	3	0
Depth	2	3

at the posterior end it gradually diminishes to the distal end.

The phalanx is slightly bent downwards; the under surface being concave longitudinally, but convex from side to side. The under surface is rough, the upper surface nearly smooth, except at the margin of the articular surface, on the projecting sides and at the distal extremity, which is sculptured by irregular vascular grooves and holes. The phalanx has a slight oblique twist to one side, and is somewhat thinned off to that side on which the curved groove is longer than on the other side.

In Mr. Saull's museum is an ungual phalanx of an Iguanodon, which nearly equals those from Horsham, and presents the same subdepressed form. The base is slightly convex transversely, more concave vertically; the articular surface is

The first and most obvious objection to the fossil in question, (No. $\frac{384}{2384}$, Mantellian Collection, British Museum), being the bony core of a median frontal horn, is its *want of symmetry*. This is plainly manifest in two respects; first, by the obliquity of the base; and secondly, hold it as you may, by the inequality and difference of form of the two sides. If the fossil be viewed with the apex upwards and forwards, as in the position in which Mr. Dinkel has delineated it, Tab. XVII, fig. 1, when I desired him to draw it in the position in which it appeared least unsymmetrical, even then the left side is, by reason of the basal obliquity, longer than the right, and it is more convex in the vertical direction. This view exposes what I believe to be the left side of the phalanx.

With respect to the base of the bone, all its natural surface, with the exception of one small spot, has been chiselled or scraped away, and the central coarse cellular structure of the bone is thus exposed. That single smooth spot, however, indicates that the base had been articulated by a synovial joint, and the form of the rest of the mutilated basal surface nowise militates against the supposition of the conical bone having been *the terminal unsymmetrical ungual phalanx* of the outer toe of a great Saurian reptile.

The want of symmetry in the ungual phalanges of the outer and inner digits of a reptile's foot, in which phalanges one side becomes longer and more convex than the other, exemplifies the nature of that degree of want of symmetry which exists in the fossil in question, and which ought of itself to be decisive against the opinion of such fossil being the basis of a single median frontal horn.

Yet this idea has been so long fixed and so generally received, that, although the objection above advanced may unsettle it, yet additional reasons may be expected before it will be finally abandoned. For, to the objection of mere want of symmetry, it may be replied, that this particular example of the horn of the Iguanodon may exhibit an accidental deviation from the normal structure; although, indeed, an unsymmetrical horn has never been noticed in the horned Iguana (*Metopoceros*). Yet even at this stage of the argument it will not be hard to decide between *a phalanx* to which the unsymmetrical form presented by the fossil is natural, and *a horn* in which such dissymmetry would be monstrous. Independently, however, of general configuration there are other characters by which an unequal phalanx of a crocodilian or other large Saurian may be detected.

An ungual phalanx is a significant bone; it has relations which no other phalangeal or other bone of a foot possesses, and has modifications of surface, of form, and structure subservient to those relations.

First, it supports the strong horny sheath or claw which immediately presses upon the ground, and which accordingly needs constant and copious reparation. An ungual phalanx, therefore, besides its own "periosteum" is invested by a highly vascular and almost glandular "corium," which is the active renovator of the worn-down claw.

All ungual phalanges of Saurian reptiles are marked on each side by a large, more or less deep and smooth groove, curved with the convexity towards the upper side of the claw. These grooves convey the blood-vessels and nerves to the matrix of the claw, and, in some species, sink at their distal end into the substance of the claw-bone.

But, it may be said, the bony basis or core of a frontal horn likewise supports a corneous sheath, and is invested by the vascular cutis which secretes that sheath. Since, however, the corneous sheath of a horn, and especially of so small a one as that which arms the head of the *Iguana cornuta*, and, as has been imagined, also of the Iguanodon, is less constantly and rapidly abraded than a claw, so the indications of the vascularity and activity of the reproductive organ are much more feebly marked upon the horn-core than upon the phalanx. They are also marked in a different manner. The horn-core is incased by its horny sheath, its base alone being free from that covering. The renovation of the horn takes place, as is well known, chiefly at the base, and the numerous vascular impressions are distributed pretty equally round the base of the core.

In the Saurian claw-bone the upper surface and sides are invested by the claw, and the renovation of the corneous matter is required near the sides of the distal half of the osseous cone. Hence in the phalanges of the large Saurian we see the large vascular curved groove extending along each side, and the canals by which the vessels and nerves emerged from the bone upon its immediately investing vascular organ of the claw are most conspicuous on each side near the apex.

Now the fossil in question exhibits conspicuously the two lateral, curved, wide and deep vascular grooves, *c*, *c'*, *d*, *d'*, figs. 1 and 2, and each groove sinks at its distal end, *c'*, *d'*, into the substance of the bone; the large oblique foramina, *e*, by which the blood-vessels and nerves emerged to supply the secreting organ of the claw are also present in greatest number on each side of the apex of the bone: these characters I hold to be decisive of the phalangeal nature of the so-called horn.

The groove on the right side of the phalanx, (fig. 2, *c*) as seen in a view of its upper surface, which is determined by the convexity of the vascular grooves, is entire: it begins about two thirds of an inch from the base, is shallow at first, but gradually becomes deeper, until it sinks into the substance of the bone (at *c'*): it presents the usual gentle and regular curve, convex upwards; its length, following the curve, is 1½ inch; it sinks into the osseous substance nearly two inches from the broken apex of the phalanx; its breadth is between 2 and 3 lines.

On the left side, fig. 1, a portion of the vascular groove, *d*, *d'*, is obliterated by the loss of part of the compact outer layer of the upper surface of the phalanx, forming the median edge of the groove, but the lateral or outer, and the terminal half inch of the groove where it sinks into the substance of the bone, as at *d'*, figs. 1 and 2, is entire: enough remains, therefore, to show that the groove on the left side of the phalanx had

the same degree and direction of curvature as that on the right side; but the left groove becomes shallower and wider towards its beginning, which may be traced as far back as the base of the phalanx, as in Mr. Saull's specimen. The vascular foramina, at and beyond the opposite termination of the left groove, are not less numerous and conspicuous than are those on the right side; but the left groove is somewhat in advance of the right, and sinks into the unsymmetrical phalanx one inch and four lines from the broken apex. At one fourth of an inch below the left vascular groove there is a shallow, smooth impression, *f*, fig. 1, along the distal half of the bone, indicating the extent to which the lateral margin of the claw reached on that side: there is no corresponding impression on the opposite side, which coincides with the dissymmetry of the phalanx, in showing it to have belonged either to an outermost toe of the left foot, or to an innermost toe of the right foot.

The exterior of the bone around its base is sculptured, as in other and normally shaped phalanges, by smaller but coarse longitudinal impressions, corresponding with the attachments and insertions of the articular capsule and ligaments. The part of the bone, proved by the direction of the large smooth lateral grooves to be the under side, is the shortest, and is most convex transversely. The upper side is the longest, and is narrower across than the under side.

	In.	*Lines.*	
The length of this phalanx is . . .	4	6	(doubtless 5 in. when entire.)
The longest diameter of its base is . .	3	3	
The shortest diameter of its base is . .	2	2	
The distance between the distal terminations of the lateral grooves	1	0*	

What might be the chances, it may be asked, that the single small bone supporting the median frontal horn should be found fossil, on the hypothesis that the Iguanodon possessed, like the *Iguana cornuta*, such a dermal appendage? Supposing an extreme toe, outermost, or innermost, of the fore and hind feet of the great reptile to have had a claw shorter and straighter than the rest, it would be four to one that the bone of such claw should be found, than the unique bone of the horn. By great good luck, indeed, the latter might once turn up; but one could not expect the only bone of its kind, and one of the smallest in the skeleton of the Iguanodon, to be frequently found. Yet I have had not less than three "horns of the Iguanodon" submitted to my inspection since describing the one so called in the British Museum. And two of these supplemental examples of straight conical claw-phalanges are figured in Tab. XVII. The first, figs. 3 and 4, was discovered in the Wealden of the Isle of

* The two figures in Tab. XVII have been made with the most scrupulous accuracy from the original fossil now in the British Museum, and exhibit characters not before given in any published figure of the so-called "horn of the Iguanodon."

the latter: it is not more curved than the first. Still the difference, which is the greatest I can detect in comparing the different ungual phalanges of the same Crocodile, is much less than that which is manifested by the depressed and compressed phalanges hitherto deemed to characterise the hind and fore feet of the Iguanodon. I think it more probable, therefore, that the second form of Wealden phalanx appertains to a distinct species from the Iguanodon, and probably to a carnivorous Saurian.

The third form is that which, less depressed than the first and less curved than the second, has been described as *the horn* of the Iguanodon. The outer border of the lateral vascular grooves are very slightly produced, and the grooves themselves commonly sink into the substance of the bone, as they do in the great phalanges of the Cetiosaurus. Some of these straight conical phalanges, *e.g.*, those figured in Tab. XVII, figs. 1, 2, 3, and 4, seem to be too large for the *Hylæosaurus*.

But I shall refrain, at present, from indulging in conjecture, however probable, as to the species of reptile to which this third form of phalanx belongs, satisfied with the present evidence of the nature of the bone itself, and that, if it ever formed part of the skeleton of the Iguanodon, it belonged to the foot and not to the head: and I shall conclude by briefly summing up the characters which ought to be borne in mind when the idea of the little modern Iguana is associated, through similarity of sound, with that of the great Iguanodon.

Both articular ends of the vertebræ of the Iguanodon are nearly flat, thereby differing more from the concavo-convex vertebræ of the Iguana than those of any existing Crocodile or Lizard do.

The anterior ribs of the Iguanodon have a head, neck, and tubercle, and a double articulation with the cervical and dorsal vertebræ; those of the Iguana and of every other existing Lizard have no cervix or tubercle, and have only a single articulation with the cervical and dorsal vertebræ. In this important modification of the anterior ribs the Crocodile has a greater resemblance and closer affinity to the Iguanodon than the Iguana has.

The height, breadth, and outward sculpturing of the neural arch of the dorsal vertebræ of the Iguanodon, are characters wanting in the Iguana and all modern Lizards, but are remotely approximated to in the dorsal vertebræ of the Crocodile, which, however, are far from presenting the expansion and complexity of the dorsal neural arches in the Iguanodon.

Five vertebræ of unusual construction are anchylosed together to form the extended sacrum of the Iguanodon: in the Iguana the small and simple sacrum consists of only two slightly modified vertebræ; in this respect it more closely resembles other Lizards, and even the Crocodiles, than it does the Iguanodon.

For the important difference in the structure of the teeth of the Iguanodon and Iguana, I refer to my former Monograph ('Cretaceous Reptiles,' pp. 115—117), and to p. 30 of the present Monograph.

collected from different localities during the last thirty years, and the collocation of some of these remains so as to prove that the entire carcase of an Iguanodon had been imbedded in the matrix, as in the case of Mr. Bensted's discovery near Maidstone, fossil bony scutes, had they existed in any quantity in the skin of the Iguanodon, might reasonably be expected to have been found associated with the parts of the endoskeleton. Such dermal bones have been discovered in connection with other remains of the *Hylæosaurus*, and we may, therefore, with more confidence assign its value to the negative evidence in the case of the Iguanodon, and conclude that the surface of its nuge body was defended by thickened epidermis, either coextensive with the chorion, or specially developed and multiplied in the form of scales.

Size of the Iguanodon.

From the comparison, which the few connected portions of the skeleton of the Iguanodon enable us to make, between the bones of the extremities and the vertebral column, it is evident that the hind legs at least, and probably also the fore legs, were longer and stronger in proportion to the trunk than in any existing Saurian. One can scarcely suppress a feeling of surprise that this striking characteristic of the Iguanodon, in common with other Dinosauria, should have been so long overlooked; since the required evidence, as pointed out in my 'Report on British Fossil Reptiles,'* is only an associated vertebra and long bone of the same individual, or a comparison of the largest detached vertebræ with the longest femora or humeri. This characteristic is, nevertheless, one of the most important towards a restoration of the extinct reptile, since an approximation to a true conception of the size of the entire animal could only be made after the general proportions of the body to the extremities had been ascertained.

It was obvious that the exaggerated resemblances of the Iguanodon to the Iguana misled the Palæontologists who had previously published the results of their calculations of the size of the Iguanodon;† and, hence, the dimensions of 100 feet in length arrived at by a comparison of the teeth and clavicle of the Iguanodon with the Iguana, of 75 feet from a similar comparison of their femora, and of 80 feet from that of the claw-bone; which, if founded upon the largest specimen from Horsham, instead of the one compared by Dr. Mantell, would yield a result of upwards of 200 feet for the total length of the Iguanodon, since the Horsham phalanx exceeds the size of the largest of the recent Iguana's phalanges by 40 times!

But the same reasons which I have assigned for calculating the bulk of the Megalosaurus on the basis of the vertebræ,‡ apply with equal force to the Iguanodon.

* Reports of the Brit. Association, 1841, p. 142.

† Mantell, 'Geology of the South-east of England,' p. 314. Buckland 'Bridgewater Treatise,' p. 243.

‡ Reports of the Brit. Association, 1841, p. 109.

resembled the Iguana in the length of its tail,* as in the anatomical characters of any of the constituent vertebræ of that part: the changes which the series of six caudal vertebræ present in the length and form of the spinous processes, and in the place of origin of the transverse processes, indicate the tail to have been relatively shorter in the Iguanodon than in the Crocodile. Assuming, however, that the number of caudal vertebræ of the Iguanodon equalled that in the Crocodile, and allowing to each vertebra with its intervertebral space 4½ inches, we obtain the length of 12 feet 6 inches for the tail of the Iguanodon. On the foregoing data, therefore, we may liberally assign the following dimensions to the largest Iguanodon:

	Feet.
Length of head, say . . .	3
Length of trunk with sacrum . .	12
Length of tail	13
Total length of the Iguanodon .	28

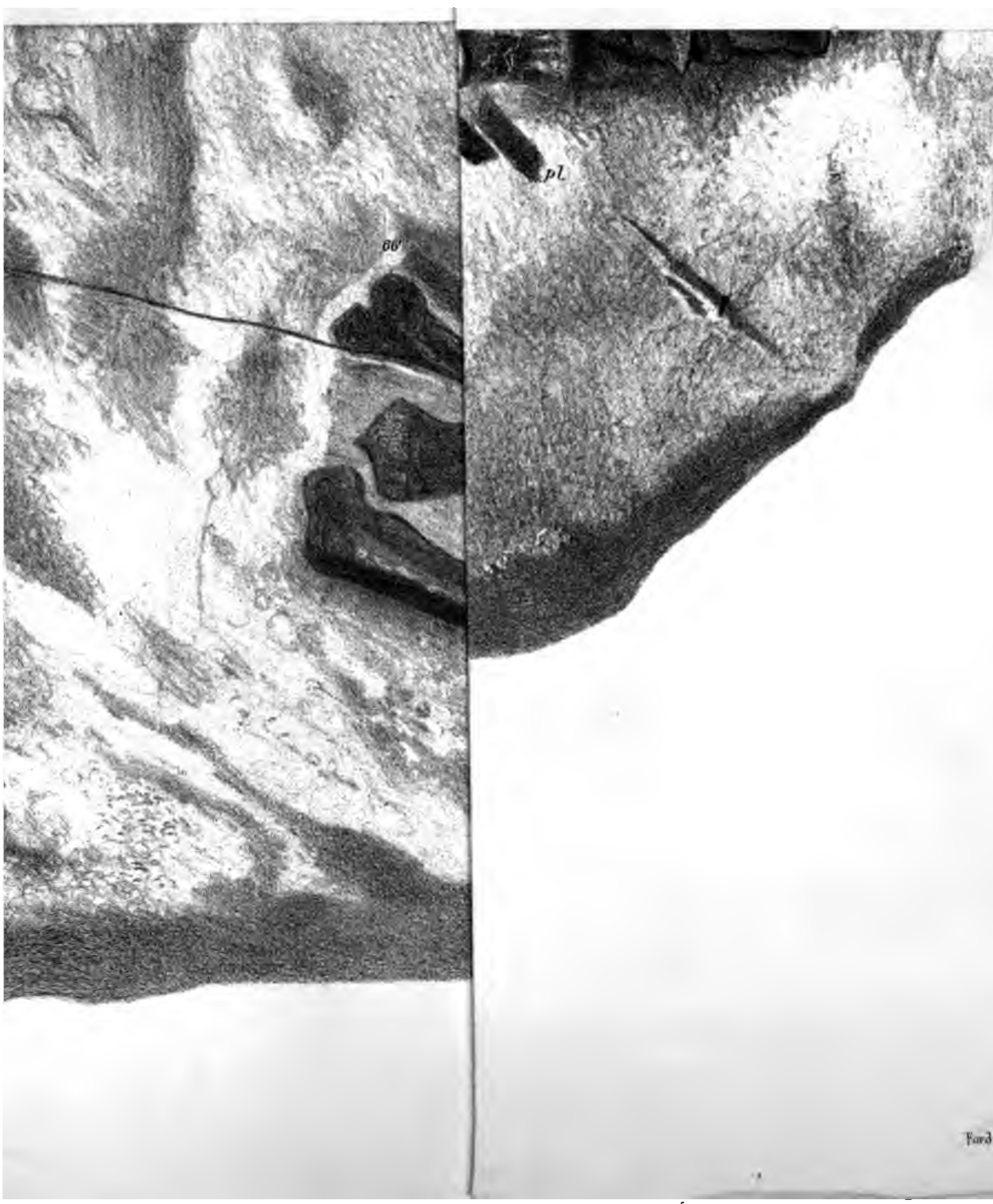
The same observations on the general form and proportions of the animal, and its approximation in this respect to the Mammalia, especially the great extinct Megatherioid or Pachydermal species, apply as well to the Iguanodon as to the Megalosaurus.

* See also the judicious remarks by Dr. Buckland to the same effect, 'Bridgewater Treatise,' p. 244.

TAB. I.

Chief part of the vertebral column, with some bones of the extremities, of a young *Iguanodon*; nat. size.

From the Wealden of Cowleaze Chine, Isle of Wight. In the British Museum, and that of J. S. Bowerbank, Esq., F.R.S.



Ford & West, Imp

TAB. II.

Iguanodon Mantelli; one fourth nat. size.

Fig.

1. Upper or vertebral portion of a thoracic rib, front view.
2. Back view of the same rib.
3. Upper view of the vertebral end of a thoracic rib, showing the ridge continued upon the long neck.
4. A considerable portion of a succeeding thoracic rib.
5. Upper view of the vertebral end of the same rib.
6. A considerable portion of a succeeding thoracic rib.
7. Upper view of the vertebral end of the same rib.
8. An almost entire rib from about the middle of the thorax.
9. An anterior thoracic rib.
10. Upper view of the vertebral end of the same rib.

From the Wealden of Tilgate forest. In the British Museum.

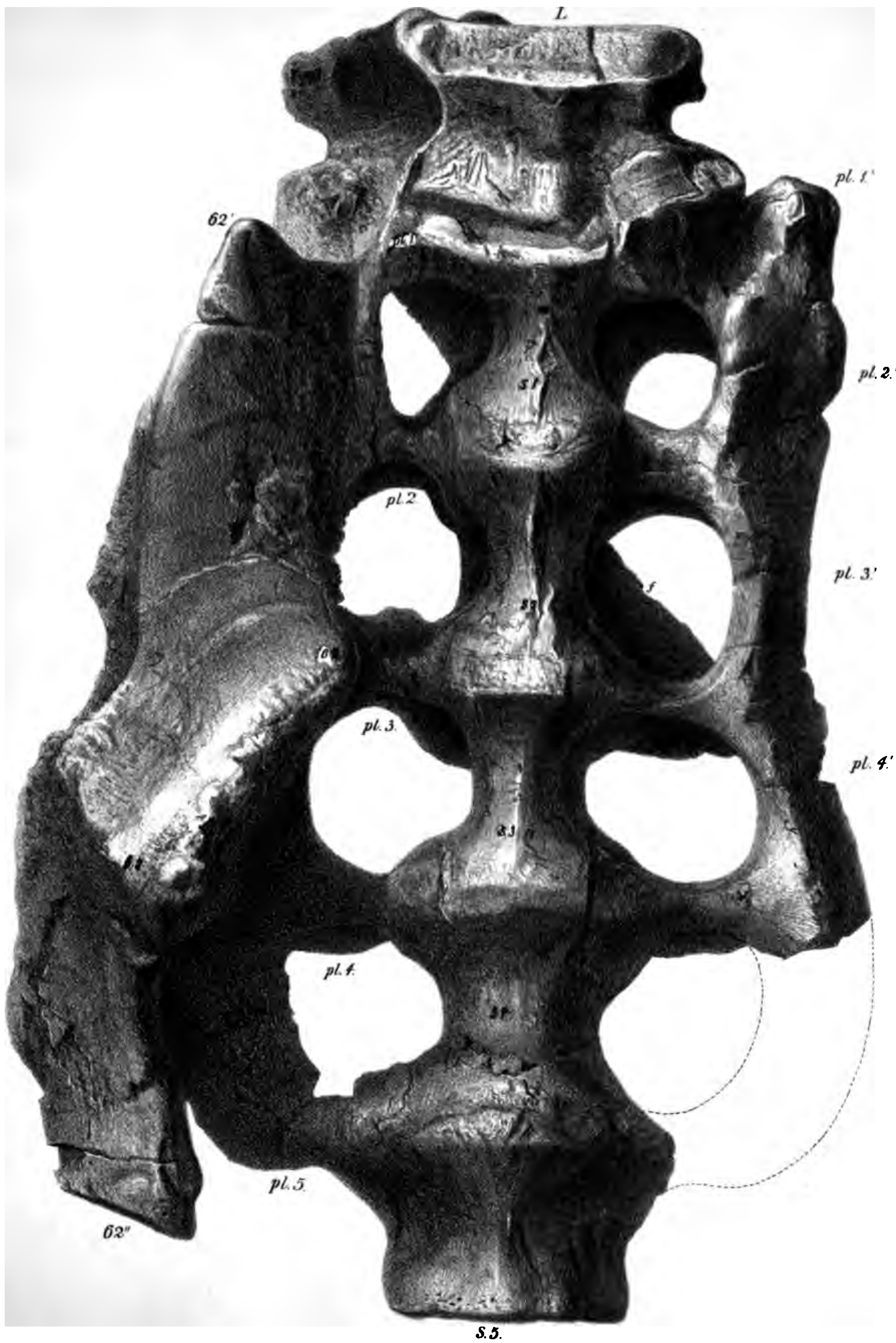
Jos. Dinkel lith.

Ford & We

TAB. III.

The inferior or ventral surface of the sacrum, and some anchylosed bones of the *Iguanodon ;* half nat. size.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.



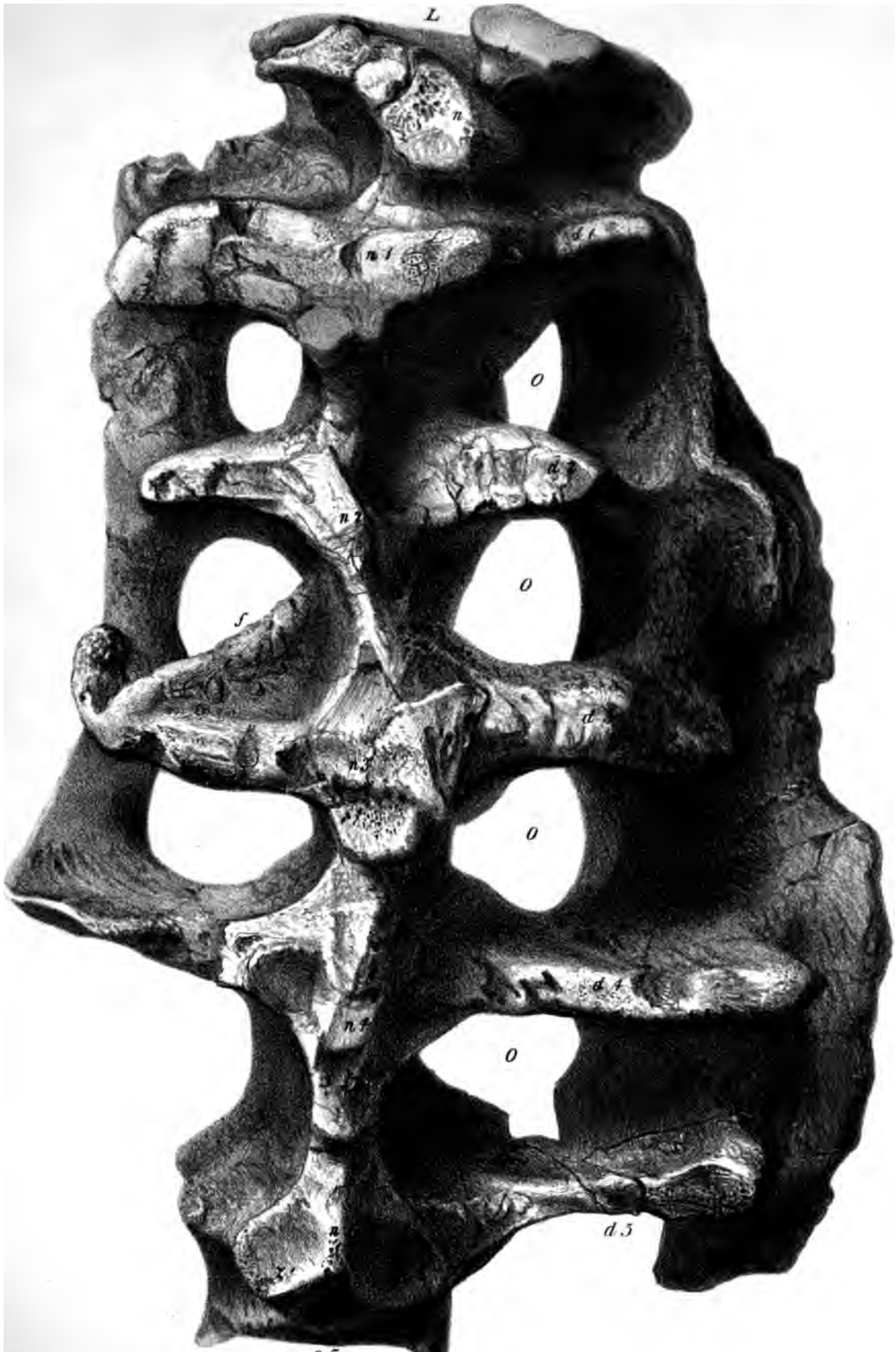
Jos Dinkel Lith.

Ford & West Imp

TAB. IV.

The superior or dorsal surface of the sacrum, and some anchylosed bones of the *Iguanodon*; half nat. size.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.



Jos Dinkel, Lith.

Ford & West, Imp.

TAB. V.

Fig.

1. Right side of the sacrum, and anchylosed ilium of the *Iguanodon*; half nat. size.

2. Left side of the sacrum, and anchylosed lumbar vertebra of the same *Iguanodon*.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.

Jos Dinkel Lith.

Ford & West, Imp.

TAB. VI.

Fig.

1. Front view of the last lumbar vertebra anchylosed to the sacrum of the *Iguanodon* ; half nat. size.

2. Back view of the sacrum with the anchylosed right iliac bone of the *Iguanodon*.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.

1

2

3

4

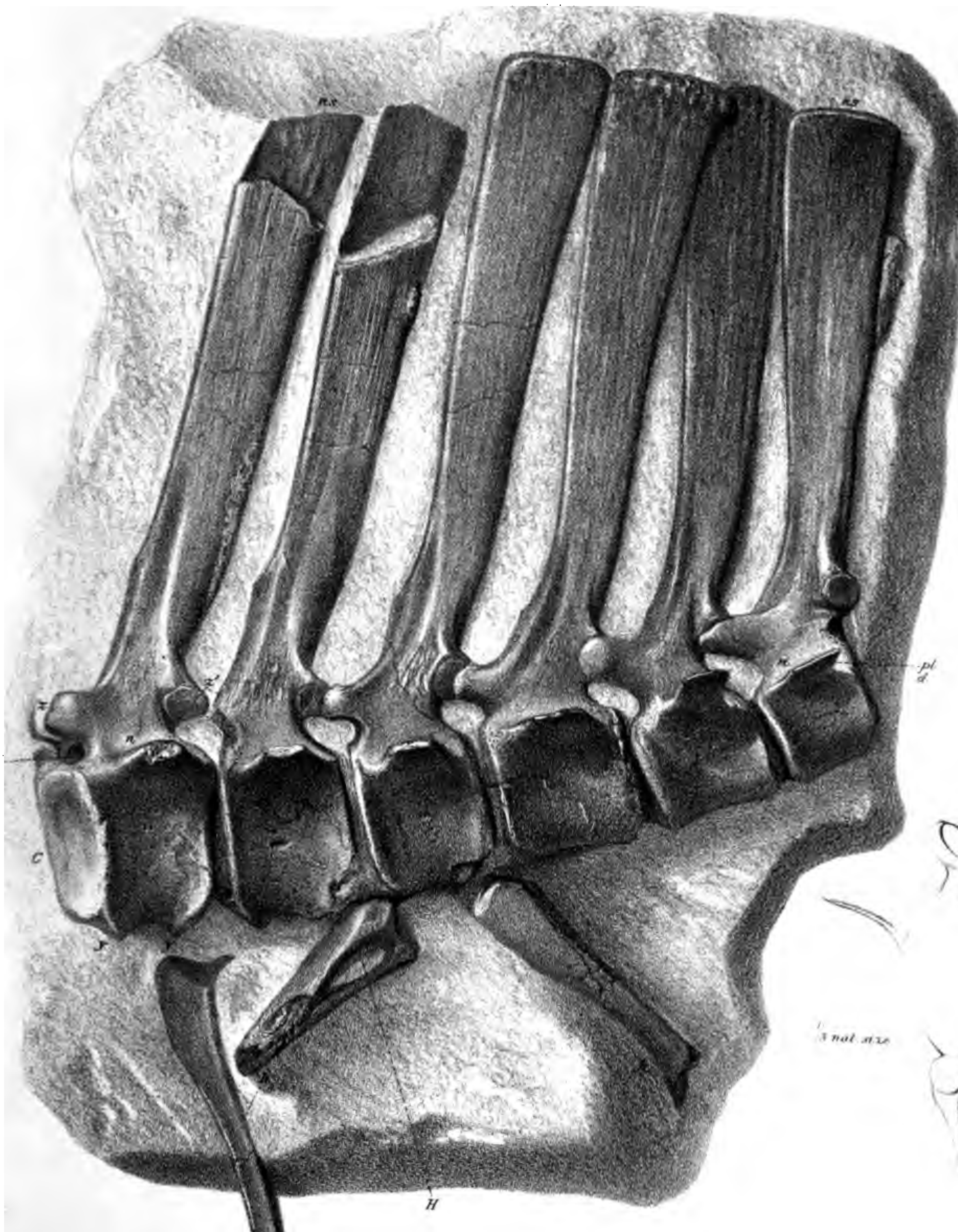
Jos.Dinkel, lith.

Ford & West Imp.

TAB. VIII.

Six consecutive vertebræ from the fore part of the tail of the *Iguanodon Mantelli ;* one third nat. size. An outline of a front view of the first of these vertebræ; restored and adjoined.

From the Wealden at Cuckfield, Sussex. In the British Museum.



1/6 nat size

1/3 nat size

Dinkel lith.

Ford & West Imp.

TAB. IX.

A vertebra probably behind the middle of the tail of the *Iguanodon;* two thirds nat. size ; the hæmal arch is wanting, and the neural spine is mutilated.

Fig.

1. Side view.
2. Upper view.
3. Front view.
4. Back view.
5. Under view.

From the Wealden at Stammerham, Sussex. In the Museum of J. B. Holmes, Esq.

TAB. XI.

The dentary part of the right branch of the lower jaw of a young *Iguanodon;* nat. size.

Fig.

1. Outside view.
2. Inside view, showing the alveolar depression, and the germs of some successional teeth.

From the Wealden of Stammerham, Sussex. In the Museum of J. B. Holmes, Esq., of Horsham.

TAB. XII.

The same portion of lower jaw, as in Tab. XI, of a young *Iguanodon;* nat. size.

Fig.

3. Upper view.
4. Under view.

From the Wealden of Stammerham, Sussex. In the Museum of J. B. Holmes, Esq. of Horsham.

TAB. XIII.

Portions of the upper and lower jaws of the *Iguanodon;* nat. size.

Fig.

1. The dentary part of the lower jaw of a large, probably full-grown *Iguanodon;* nat. size.

   From the Wealden of Tilgate, Sussex. In the British Museum.

2. The outer side of a portion of the back part of the left superior maxillary bone of a probably full-grown *Iguanodon;* nat. size.
3. The inner side of the same specimen.
4. The cut surface of a vertical section taken through the fore part of the same specimen.

From the Wealden near Brook-point, Isle of Wight. In the British Museum.

1

Ford & West

TAB. XIV.

Iguanodon Mantelli; one third nat. size.

Fig.

1. The scapula and coracoid (the upper end is downwards in the figure).
2. An end view of the same specimen showing the coracoid.
3. Front view of the humerus of the same individual.
4. Side view of the same humerus.
5. Back view of the lower half of the same humerus.
6. Condyles of the same humerus.

From the Wealden at Rusper, Sussex. In the Museum of J. B. Holmes, Esq.

TAB. XV.

Iguanodon Mantelli; one fourth nat. size.

Fig.

1. Front view of the right femur: 1*a*, Outline of the head of the bone: 1*b*, Outline of the condyles of the bone.
2. Back view of the right tibia of a somewhat larger individual.

From the Wealden of Tilgate Forest, Sussex. In the British Museum.

3. Outside view of the fibula of a younger Iguanodon.
4. Inside view of the same bone.
5. Front view of the same bone. (The upper end of the bone is downwards in these figures.)
6. Lower end of the same bone.
7. Upper end of the same bone.

From the Wealden of Sussex. In the Museum of J. B. Holmes, Esq., of Horsham.

8. A slightly magnified view of the surface of a piece of the corium or true skin of the *Iguanodon*.

From the specimen in Tab. I; from the Wealden of Cowleaze Clime. In the Museum of J. S. Bowerbank, Esq., F.R.S.

TAB. XVI.

Fig.

1. A first or proximal phalanx of one of the toes of an *Iguanodon;* nat. size.
2. A last or ungual phalanx of one of the toes of an *Iguanodon;* nat. size.

From the Wealden of the South coast, Isle of Wight. In the Geological Museum of Oxford.

TAB. XVII.

Ungual phalanges of modified shape, probably from the extreme toe, outer or inner, of the hind foot of the *Iguanodon*.

Figs. 1 and 2, are of the specimen called '*Horn of the Iguanodon*,' in the Works and Catalogue of Dr. Mantell.

From the Wealden, Sussex. In the British Museum.

Fig.

3. Side view of a similarly shaped phalanx.
4. Upper view of the same phalanx.
5. Upper view of a smaller and similar phalanx.

From the Wealden of Battle, Sussex. In the Museum of Felix Knyvett, Esq.

TAB. XVIII.

Different views of the teeth from the upper and lower jaws of the *Iguanodon;* figs. 1—7, nat. size: figs. 8 and 9, highly magnified views of sections, showing structure.

From the Wealden of Tilgate Forest; and Cuckfield, Sussex. In the British Museum.

TAB. XIX.

Megalosaurus Bucklandii; nat. size.

Three anterior dorsal vertebræ: *p*, parapophysis, or lower transverse process: *t*, accessory tubercle contributing some attachment to the head of the rib: *d*, diapophyses, or upper transverse process, fractured; which gave attachment to the tubercle of the rib: *b*, oblique buttress extending from the parapophysis to the diapophysis, and contributing to the support of the neural platform: *z*, the prozygapophysis, *z'*, the zygapophysis, forming the ends of the neural platform and articulating the neural arches of the vertebræ with each other, *ns*, the neural spine of the foremost of these vertebræ, *ns'*, the neural spine of the second vertebra; it expands at its extremity, overhangs the anterior shorter spine, and developes a strong bony plate from its back part which fixes it to *n''*, the similarly developed and modified spine of the third vertebra.

The extraordinary size and strength of the spines of these anterior dorsal vertebræ, indicate the great force with which the head and jaws of the Megalosaurus must have been used.

From the Wealden, near Battle. In the Museum of Samuel H. Beckles, Esq., F.G.S.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

PART III.

PAGES 1—26; PLATES I—XII.

DINOSAURIA (MEGALOSAURUS).

[WEALDEN.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1857.

more or less resemble those of the horny pachydermal mammals, and attest, with the hollow long bones, the terrestrial habits of the species.

Of these gigantic *Dinosauria* the most formidable was that which its discoverer, that keen observer and original thinker, the Rev. Dr. Buckland, has called "Megalosaurus,*" in reference to the idea of its hugeness, which was suggested to both him and Baron Cuvier by certain of its limb-bones. "Si l'on pouvait donner," writes Cuvier, "le nom de *Lacerta gigantea* à un autre animal qu'à celui de Maëstricht, c'est l'espèce actuelle qui le mériterait; son seul fémur, long de trente-deux pouces anglais ou 0·805; annoncerait, en lui supposant les proportions d'un Monitor, une longueur totale de plus de quarante-cinq pieds de roi, et même, s'il y a de ces fémurs de quatre pieds et plus, comme on l'a dit, sa longueur serait encore plus étonnante."†

The locality where the first rightly recognised remains of the *Megalosaurus* were found was Stonesfield, near Woodstock, about twelve miles from Oxford. The formation is that calcareous schist, which, being quarried for roofing houses principally at Stonesfield, is called, in most English geological works, "Stonesfield slate." Its position is at the base of the great Middle Oolitic series, where it may be, perhaps, more accurately classed as an upper member of the Inferior Oolite.

To get at this slate, pits are sunk through forty-feet or more of superincumbent strata, chiefly consisting of that hard oolitic rock called "cornbrash" by the quarry-men. The schistose or slaty deposit is not more than six feet thick; and the scepticism with which the first announcement of bones of large animals in stony strata at that depth was received, is exemplified by the stress with which Cuvier thought it needful to insist on the fact that the Stonesfield slate was as regular a formation as it was an ancient one, and that there was no ground for supposing that the fossil bones which it contained had penetrated it by any fissure or other accidental opening.

The portions of skeleton originally discovered, and attributed by Dr. Buckland to his newly defined genus, *Megalosaurus*, consisted of a fragment of the lower jaw, a femur, a series of five vertebræ of the trunk, a few ribs, a coracoid bone, a clavicle, and some less certainly recognisable fragments.‡

Unfortunately, as Cuvier has remarked, those portions were not found together in one spot, nor, with the exception of the five vertebræ, were the bones associated two to two, or three to three, so as to make it probable that they belonged to the same individual; and, with regard to their zoological or anatomical relations, Cuvier further observes that these are of a somewhat equivocal and mixed nature, "encore ces rapports zoologiques sont-ils d'une nature assez equivoque et assez mélangée."§

* See 'Transactions of the Geological Society of London,' 4to, vol. i, 2d ser., pt. 2, 1824.

† 'Ossemens Fossiles,' 4to, vol. v, pt. 2, p. 343.

‡ 'Geological Transactions,' vol. i, 2d ser., p. 427.

§ Tom. cit., p. 345.

with the original series of Megalosaurian remains, have sufficed for the determination of subsequently discovered and better-preserved specimens of detached vertebræ of the Megalosaurus from other localíties.

Dorsal vertebræ.

The Megalosaurus departs, perhaps even more than does the Iguanodon, from the existing Crocodiles, Monitors and Lizards, in its vertebral characters. The articulating surfaces of the vertebral bodies are very slightly concave, indeed almost flat, presenting in that respect the type of the Amphicœlian Crocodiles: the non-articular surface is remarkably smooth and polished. The centrum is much contracted in the middle, presenting a deep concave outline of the under surface: the margins of the expanded articular extremities are thick and rounded off. The almost cylindrical section of the middle part of the vertebra arises from its being nipped in, as it were, by a more or less deep longitudinal fossa on each side, just below the base of the neural arch; the centrum, however, slightly expanding above the fossa to support the arch.

The length of the base of the neurapophysis is nearly equal to that of the centrum; the suture is persistent, as in Crocodiles; its course is undulating, and it rises in the middle of the centrum. The neurapophysis ascends and inclines outwards, to form, at a height above the centrum equal to three fourths its vertical diameter, the margin of a broad platform of bone, from the sides of which the upper transverse processes (diapophyses) are developed, and from the middle of the upper surface the spinous process. A recent discovery has shown the extraordinary development of the latter apophysis in some of the anterior dorsal vertebræ.

In the Wealden deposits at Battle, Sussex, a large nodule of the ferruginous clay had been formed and consolidated around a portion of the skeleton of a *Megalosaurus* consisting of some anterior thoracic vertebræ. In the state in which this nodule was submitted to my examination, three almost entire and consecutive vertebræ, wanting the ribs, were preserved in natural juxtaposition. A figure of this unique specimen, discovered by S. H. Beccles, Esq., F.G.S., was, with his kind permission, given in a preceding Monograph.* In a second portion of the same nodule two almost entire and consecutive ribs of the right side were preserved: a smaller fragment contained the bodies and neural arches of two consecutive vertebræ in natural junction from a more anterior part of the chest than the series of the three vertebræ (*loc. cit.*, pl. xix). Two detached vertebræ, wanting the spinous process, from a hinder portion of the trunk, had been obtained either from, or near to, the above-described large nodule.

* 'Palæontographical Society,' 1855, t. 19.

to within a third of its hinder border, which is flat: the whole height of this spine is nine inches, the vertical extent of the entire vertebra being thirteen inches six lines. The spine of the second vertebra, *ns*, 1, has a similar size and shape in the basal third of its extent, but it expands more gradually, especially transversely, and rises to a greater height, continuing to expand in every direction, but especially in the antero-posterior one; the fore part of its thick extremity being produced so as to overlap the horizontal part of the end of the shorter spine in front. The sides of the thick expanded end of this clavate spine are impressed by irregular decussating ridges, indicative of the attachment of strong tendons or ligaments; and, from the back part of the side, six inches below the summit, there projects a tuberosity: a less prominent tuberosity forms the border of the overlapping anterior part of the clavate end of the spine. The whole length of the spine is 13 inches 6 lines; the vertical extent of the entire vertebra being 18 inches 6 lines.

The neural spine of the third vertebra, *ns*″, is somewhat smaller than the foregoing at its most contracted part, three inches above its origin; but it expands, as it rises, attains a height of 14 inches, and is divided, like the foregoing, into a smooth part, and a summit impressed by the attachments of the nuchal ligaments or tendons. The base of the latter part developes a tuberosity from the fore part and back part of its outer side, and there are indications of ossifications in the interspace between it and the antecedent spine, which seem to have bound them immoveably together.

The proportions and external configuration of the spines of these anterior dorsal vertebræ, the sudden increase of the second spine, the further increase of the third, with the indications of the strength of the muscles or nuchal ligaments to which their expanded tuberculate summits have given attachment,—all recall characters of the spines of the anterior thoracic vertebræ of certain great Mammalia, and much more closely resemble those parts in the tiger or rhinoceros than in the crocodile, the gavial, or in any of the known existing Lizards. But the production of the summit of the second spine, so as to overlap part of that of the first spine, and the partial anchylosis of the second with the third spine, together with the great increase in the thickness of all the spines toward their summit, are characteristics in a great measure peculiar to the present extinct Dinosaurian; unless, indeed, it participated in them with some other members of the same extinct order of reptiles.

We cannot view this remarkable configuration of the anterior thoracic vertebræ of the Megalosaur without being impressed by an idea of the great strength of the muscles or ligaments—more probably of the energetically contracting muscles—which were implanted in those thick and lofty spines, from which, as from a fixed point, they acted upon the nuchal region of the head. The remarkable fossil, therefore, above described, yields some insight into the vigour with which such a head, consisting chiefly of the well-armed maxillary and mandibular apparatus, must have been made to operate on the bodies which the instincts of the Megalosaurus impelled it to grapple with and

The neural arches of the first three sacral vertebræ, *ns* 1, 2, 3, have been advanced so as to rest directly over the interspaces of the subjacent bodies; that of the fourth, *ns* 4, derives a greater proportion of its support from its proper centrum, *c* 4; and that of the fifth, which rests by its anterior extremity on a small proportion of the fourth centrum, is extended over nearly the whole length of its own centrum, so that in the caudal vertebræ the ordinary relations of the neural arch and centrum are again resumed. In the first four sacral vertebræ the base of the neural arch extends half way down the interspace between the bodies, and immediately developes from its outer part a strong and short transverse process, or parapophysis, *p*, which is broken and rounded off in the fossil. From the base of this process the neurapophysis expands upward, forward, and backward, is joined by vertical suture to similar expansions of the contiguous neurapophyses, and terminates above in a ridge of bone, *d*, *d*, at right angles to the suture; this ridge, with those of the other neurapophyses, extends longitudinally above the parapophyses the whole length of the sacrum, and forms the margin of the platform from which the spinous and accessory processes are developed: in the last sacrum the corresponding part forms a thick, obtuse process, or diapophysis *d*, 5. The platform is further supported by a compressed ridge of bone extended from the upper part of the parapophyses, like a buttress, to the middle of the horizontal ridge. On each side of the buttress there is a depression, which is deepest in front. The spinous process is not developed, as in the dorsal vertebræ, immediately from the platform, but a shorter, vertical plate of bone, a metapophyses, *m*, of nearly the same longitudinal extent as the true spine, is developed on each side of, and parallel with its base; the height of these metapophyses in the third sacral vertebra is three inches and a half; they incline obliquely outwards, like the metapophyses in the dorso-lumbar vertebræ of the armadillos, and evidently tend to strengthen the connection between the sacral part of the trunk, and the pelvic base of articulation of the hind limbs. The spinous process begins to expand longitudinally, and when nearly opposite the summit of the metapophyses, is joined by vertical suture with the similarly expanded neighbouring spines, so that the sacrum is crowned by a strong continuous vertical longitudinal ridge of bone, at least along the first four vertebræ; the broad spine of the fifth being rounded off anteriorly, and separated by a narrow interspace from that of the fourth. Besides this modification of the spine, and the more normal position of the neural arch, the diapophysis, *d*, of the fifth anchylosed vertebra, resumes its more ordinary shape, and it is supported by two converging ridges of bone from the side of the neural arch below. The origin of the metapophysis, *p*, of the first sacral is placed higher than in the three middle ones, in which the several peculiarities of structure above described are most strongly marked.

The specimens of sacrum of the *Megalosaurus* in the British Museum, and that of the Geological Society, present the same structure as that above described in the original specimen at Oxford. Part of the fifth sacral vertebra is wanting in the

The five sacral vertebræ are not anchylosed in a straight line, but describe a gentle curve, with the concavity downwards; the series of parapophyses, or sacral ribs, forms a curved line in the opposite direction, in consequence of their different positions in the several vertebræ. The summits of the anchylosed spines being truncated, describe a curve almost parallel with that of the under part of the vertebræ.

The contour of the hinder part of the body of the present gigantic carnivorous Lizard, doubtless raised high above the ground upon the long and strong hind-legs, must have been different from that of any existing Saurians. In these the relatively shorter hind-legs, being directed more or less obliquely outwards, do not raise the under surface of the abdomen from the ground; it is the greater share in the support of the trunk assigned to the hind-legs in the Megalosaur which made it requisite that, as in the Iguanodon and in land mammals, a greater proportion of the spine should be anchylosed to transfer the superincumbent weight through the medium of the iliac bones upon the femora.

In the caudal vertebræ the parapophyses are suppressed, and the single transverse process is formed by the diapophysis being lengthened out by the anchylosed rudiment of a rib. The hæmal arch was articulated to the lower part of the vertebral interspaces, but chiefly to the anterior vertebra.

Ribs. Tab. IV.

The ribs which, from their size, texture, and colour, as well as from their proximity in the matrix to other more characteristic parts of the Megalosaurus, belong most probably to the same species of reptile as the vertebræ above described, present a double articulation with the vertebral column.

The specimen, fig. 1, from the Stonesfield Oolite, and now preserved in the Museum at Oxford, has a small, almost flattened, obtuse head, *c*, for articulation with a parapophysis; the neck is long, and soon begins rapidly to increase in vertical thickness, being strengthened, also, by a longitudinal ridge on one side. It developes a thick, obtuse tubercle, *t*, larger than the head, for the diapophysis. The body of the rib gradually contracts, with a slight curve, to a point. The length of the body of this floating rib, is little more than twice that of the neck and tubercle, showing that it must have belonged to a hinder cervical or anterior dorsal vertebra.

A second specimen, fig. 2, from the Stonesfield slate, shows a longer body, a neck set on more transversely, and less expanded beneath the tubercle. The upper margin of the neck is sharp; the body of the rib is strengthened by a lateral ridge, and becomes compressed in such a direction that those ridges form its margins towards the lower end; this terminates so as to indicate its having been joined to an abdominal rib.

The upper portion of a rib from a larger specimen of Megalosaurus, and from a more expanded part of the thoracic abdominal cavity, T. IV, fig. 3, formed, with fig. 1, part of the original series of fossil bones, from the Stonesfield slate, de-

which form part of Mr. Holmes's instructive collection, it is possible that the blade-bone in question may belong to that genus; but I insert the description of it here with a full sense of the inadequacy of our present evidence for the precise determination of the scapula of the Megalosaurus.

The body of the bone is an oblong flattened plate, proportionally broader and shorter than in the Iguanodon; with the base rounded, not truncate as in the Hylæosaurus; and with the anterior border at first, as it descends, straight and then concave, not convex, as in the Hylæosaurus. The body of the scapula slightly decreases in breadth as it approaches the articular end, near which there is continued from the anterior border a long and slender process, at least three fourths the length of the entire bone, but the precise proportions of which cannot be determined in this specimen, because the extremity of the process is broken off. Near the base of the process a tuberous projection is developed, which touches the anterior angle of the articular end of the scapula, circumscribing an elliptical vacuity probably for the transmission of vessels. The thickened articular extremity shows indications of a division into two surfaces, one for the coracoid, the other for the humerus.

The coracoid. Tab. VI.

The coracoid is a long and large semioval plate of bone, 2 feet 6 inches in length, 1 foot 4 inches in greatest breadth; with the inner (mesial) border thin and regularly but very slightly convex, the upper border thin and strongly convex, the outer (lateral) border thick and made irregular by the development of processes, grooves, and articular surfaces. The latter are two in number: the largest and deepest, fig. 1, *o*, *l*, for the head of the humerus, the smallest and shallowest, *o*, *o*, for junction with the scapula.

This surface, which is hollowed out, groove-wise, chiefly in one direction, is supported by a very strong, thick, three-sided process, *n*, *o*, a little expanded towards its free end, and contributing by its hinder surface, *o'* to the formation of the glenoid cavity, in front of which it projects to meet the blade-bone. The length of this process is about 6 inches: its circumference is 13 inches; the length of the scapular articular surface, fig. 2, *o*, is 6 inches. A deep oblique notch, fig. 1, *n*, divides the scapular process, *o*, from the thin anterior part of the coracoid, *c*, *s*, the convex border of which is entire.

In some existing Lacertians, *e*, *g*, the Monitor and Iguana, a second process is sent off from this part, for articulation through the medium of an epicoracoid cartilage with the episternum; and the mutilated state of the first-discovered specimen of coracoid of the Megalosaurus, figured by Dr. Buckland in pl. xliii, fig. 3, vol. i, 2d series of the

The clavicle. Tab. IV, fig. 4.

A slender sigmoid bone, nearly two feet in length, from the Stonesfield slate, now in the Geological Museum at Oxford, T. IV, fig. 4, was referred, by the discoverer of the *Megalosaurus*, to that species,* from its resemblance to the clavicle in certain Lizards, especially, as Cuvier remarks, who concurs in this determination with Buckland, to the clavicle of the great scincoid Lizard.† It is, however, less bent upon itself than in that existing Saurian, and bears a closer resemblance to the clavicle of the *Iguanodon*.‡ The more expanded median or pectoral extremity of the bone in question has one margin fractured, that which corresponds with the margin from which the two processes are developed in the clavicle of the Iguanodon: how far, therefore, the Megalosaurus resembled the Iguanodon in the form or even existence of those processes cannot at present be determined. The shaft of the clavicle presents a similar gentle sigmoid curve, but is relatively thicker and more bent than in the Iguanodon; its transverse section is subtrihedral: the outer or scapular end is more expanded; the sternal end is more rounded or convex. With respect to the present bone, Cuvier has remarked that according to the proportions of the clavicle in existing Lizards, it bespeaks an animal nearly sixty feet in length,§ but the proportions of the trunk to the limb-bones alter with the increasing bulk in different species of the same family or order, and we shall presently show that there are surer grounds for arriving at the true bulk of the Megalosaurus, than the comparison of its limb-bones with those the small existing Lizards affords.

The ischium. Tab. IV, fig. 5.

The subcompressed, three-sided bone, flattened and expanded at one end, thickened and less expanded at the opposite end, which formed part of a large cotyloid cavity, has most claims to be regarded as the ischium of the Megalosaurus. This bone, now in the Geological Museum at Oxford, formed part of the original series obtained from the Oolitic slate at Stonesfield, and described by Dr. Buckland.‖

The longest diameter of the bone is 18 inches; the breadth of the almost straight, thin, mesial border, is about 14 inches, but the angles are somewhat mutilated; the narrow even flattened surface of this border appears to have joined, probably with some interposed fibro-cartilaginous matter, to the corresponding margin of the opposite ischium.

* Buckland, loc. cit., pl. 44, figs. 3 and 4.

† 'Ossemens Fossiles,' 4to, tom. v. pt. ii, p. 347.

‡ Palæontographical Society, vol. for 1851, 'Reptilia of the Chalk,' Tab. XXXIII; and vol. for 1854, p. 33.

§ 'Ossemens Fossiles,' p. 348.

‖ Loc. cit., p. 427, pl. 43, fig. 4.

The Tibia. Tab. IX.

The specimen, from which the reduced figures have been taken in the above plate, is the most perfect one of the tibia of the Megalosaurus which has hitherto come under my notice: it originally formed part of the collection of Megalosaurian remains from the Stonesfield slate, acquired by the Earl of Enniskillen, whilst an undergraduate at Oxford, and is now in the British Museum.

Fig. 1 gives a side view of the bone, with a top view of the upper articular surface. The divisions corresponding with the condyles of the femur project from the back part of the proximal end, which gradually contracts towards the fore-part where it assumes the character of a process, answering to the procnemial ridge in the tibia of birds, but it is a little inclined inward. The articular surface is a little concave at its middle part and becomes convex, in a moderate degree, upon the condyles. A thick cartilage appears to have covered the whole of this surface, and the softer bone in contact with the cartilage has been, as in most fossil reptilian long bones, more or less abraded, especially at the margins of the articulation. The backward position and production of the corresponding articular prominences or condyles in both femur and tibia, indicate that these bones were joined together at an angle, probably approaching a right one, when in their intermediate state between flexion and extension: and that motion of the tibia in the latter direction could not have taken place to the extent required to bring the two bones in the same line. A moderately developed longitudinal ridge, fig. 2, *c*, extends from the inner side of the upper fourth of the shaft of the tibia, the homologue of which is present in the tibia of the great Monitor. Below this the shaft of the tibia assumes a sub-trihedral figure, with the angles unequally rounded off, fig. 3; it very gradually decreases in breadth, from before backwards, to within a short distance of the lower end: the transverse diameter remains the same. The expansion of the lower articular end is chiefly in the latter direction, *i. e.*, at right angles with the long diameter of the proximal end: the inner angle of the distal end is the most produced. The form of the articular surface for the tarsus is a rhomboid, with two shallow depressions, but in the main is moderately convex.

The length of the bone above described is 26 inches: its shaft, like that of the femur, has a medullary cavity, but the compact walls are relatively thicker in the tibia.

The above-described bone, from the Oolitic slate of Stonesfield, presents all the main Dinosaurian characters, which have been described, in a preceding Monograph, in the tibia of the *Iguanodon.** From that tibia the present bone differs in its

* Monog. cit., p. 39.

The articular surface is deeply concave in the vertical direction, indicative of a strong joint and a certain extent of vertical motion, or of retraction and protrusion. Beneath the articular surface is a large rough process or protuberance for the insertion of a powerful flexor tendon. The margin of the articular pulley is slightly raised and roughened, for the attachment of the capsular ligament. The base of the claw-bone is longitudinally striated; the rest of the surface is smooth, and offers the same compact character and colour which are commonly found in the bones of the Megalosauri. On each side of the bone, nearer the lower border, and rather lower down on one side than on the other, is a deep smooth groove, running parallel with the lower concavity of the bone. These grooves indicate the position of the borders of the horny matter of the claw, and also, of the vessels supplying the reproductive matrix of that matter.

A smaller phalanx of the same type with one side imbedded in a block of Wealden sandstone, fig. 5, shows the whole length, and the sharp-pointed termination of the bone supporting the formidable claw.

Both the above-described specimens are in the British Museum.

Mandible and Teeth. Tabs. XI and XII.

The most important evidence of these highly characteristic parts of the Megalosaurus is the portion of the dentary element of the mandible or lower jaw, from the Stonesfield slate, preserved in the Geological Museum at Oxford, and forming part of the original series of bones described by Dr. Buckland.* This specimen is represented, of the natural size, in T. XI, fig. 1, from the inner side: a portion of the outer side of the same specimen is given in fig. 2. The entire depth of the ramus of the jaw is not, however, represented by this specimen: a broad and shallow groove along the under and inner surface of the bone indicates where the angular element of the mandible had articulated with this hinder portion of the dentary piece. The portion of the dentary element from a more advanced part of that bone, represented in T. XII, affords a truer idea of the vertical diameter of the mandibular ramus of the Megalosaur.

The first character which attracts the attention of the anatomist, in the Oxford specimen (T. X), is the inequality in the height of the outer and inner alveolar walls. This assures him of the saurian affinities of the gigantic reptile; a similar inequality characterising the jaws of almost all the existing Lizards. But in these the oblique groove, so bounded, to which the bases of the developed teeth are anchylosed, is much more shallow, and is relatively wider; and the teeth, in all their stages of growth,

* Loc. cit., pl. 40.

inch, with interspaces varying between two and three times that diameter. They radiate from the pulp-cavity at right angles with the external surface of the tooth. The primary curvatures correspond with those of the dentinal tubules in the *Varanus*, figured in my 'Odontography,' pl. 67, fig. 2; but they are less marked, so that the tubules appear straighter in the Megalosaurus. After their origin they dichotomize sparingly, but the number of minute secondary branches sent off into the intermediate substance is very great. These secondary branches proceed at acute angles from the primary tubules; the divisions of the latter become very frequent near the periphery of the dentine, and the terminal branches dilate into, or inosculate with, a stratum of minute calcigerous cells, which separates the dentine from the enamel.* No part of the dentine is pervaded by medullary canals, as in the Iguanodon.

A series of teeth from individual Megalosauri of different ages has been selected from specimens in the British Museum, and in the Geological Museum at Oxford, progressively diminishing in size, but preserving the same characteristic form, from fig. 4 to fig. 9, inclusive, T. XI. Fig. 3 shows a specimen, imbedded in Stonesfield slate, which shows a somewhat more slender termination than usual. Fig. 11 is a much-worn and shed tooth, apparently of a small-sized Megalosaurus, in which both the point and the trenchant margins had been rubbed down to a smooth obtuse surface: it may have come from the hinder part of the dental series, where the teeth may have been smaller and less sharp, or more liable to be blunted by a greater share in the imperfect act of mastication than the teeth in advance.

Successional teeth, in different stages of growth, are shown in the original portion of jaw of the Megalosaurus in the Oxford Museum. Some more advanced, as at *b*, fig. 1, T. XI, show their crowns projecting from alveoli already formed by the plate extending across from the triangular processes before described. Vacant sockets from which fully formed teeth have escaped occur, generally in the intervals between these more advanced teeth. The summits of less developed teeth are seen protruding, as at *c*, *c*, at the inner side of the basal interspaces of the triangular plate, between them and the true internal alveolar parapet. There can be no doubt that, in the course of the development of these teeth, corresponding changes take place in the jaw itself, by which new triangular plates and alveolor partitions are formed, as the old ones become absorbed, analogous to these concomitant changes in the growth and form of the teeth, alveoli, and jaws, which take place in so striking a degree in the Elephant.†

The peculiarity of the Megalosaurus, as compared with the Crocodiles and Lizards

* The microscopic characters of the tooth of the Megalosaurus are represented in my 'Odontography,' pl. 70 A, in part of a transverse section of the middle of the crown, including the pulp-cavity and its osteodentine.

† See 'Odontography,' p. 625.

teeth enabled them to retain, like barbs, the prey which they had penetrated. In these adaptations we see contrivances which human ingenuity has also adopted in the preparation of various instruments of art."*

Size of the Megalosaurus.

A few words may be added touching the size of the Megalosaurus; for it appears to me that the calculations which assign to it a length of 60 and 70 feet are affected by the fallacy of concluding that the locomotive extremities bore the same proportion to, and share in the support of, the body, as they do in the small modern land Lizards.

The most probable approximation to a true notion of the actual length of the Megalosaurus is that which may be obtained by taking the length of the vertebræ as the basis. The antero-posterior dimension is the most constant which the vertebræ present throughout the spine: in most Crocodilian and Lacertian reptiles the cervical vertebræ are a little shorter than the dorsal; but these are of equal length, and the caudal vertebræ maintain the same length, though decreasing in other dimensions, to very near the extremity of the tail.

As the dorsal vertebræ of the Megalosaurus agree, in the important character of the mode of articulation of the ribs, with the Crocodiles, it may be regarded as most probable that they also corresponded in their number. This does not exceed 14 in recent Crocodiles, nor 16 in any of the known extinct species; taking, then, the latter number, and adding to it 7, the usual number of the cervical vertebræ in Crocodiles, we may allow the Megalosaurus 23 vertebræ of the trunk.

The length of the body of a large dorsal vertebra of the Megalosaurus, in the British Museum, is 4½ inches: from the analogy of the Iguanodon I was led, in my original calculations,† to allow a probable thickness of the intervertebral substance one third of an inch: but if we multiply 23 by 5, not allowing for the probable shortness of the cervical vertebræ, we only then attain a length of 9 feet 7 inches. The subsequent discovery of the coadapted dorsal vertebræ, figured in T. xix, *loc. cit.*, shows that their bodies were not separated by soft substance of more than 1 line in thickness. If, moreover, setting aside the analogy of the Megalosaurus to the Crocodiles in the structure of the vertebræ, we take that species of Lacertian which it most resembles in the structure of the teeth, and found our calculation on the number of vertebræ of the trunk in such Lizard, then, the great carnivorous Varanian Monitor

* Buckland, 'Bridgewater Treatise,' vol. i, p. 237.

† Report on British Fossil Reptiles, 'Trans. Brit. Association,' 1841.

the Cornbrash and Bath Oolite immediately above that slate, and in Oolites beneath it. A tooth of a Megalosaurus has been kindly communicated to me by Mr. Woodward, of the British Museum, which was found in the Inferior Oolite of Selsly Hill, Gloucestershire, which is separated from the Stonesfield Oolite by superimposed deposits of Fullers' earth one hundred feet in vertical extent. Vertebræ and parts of long bones of the Megalosaurus have been found in the Inferior Oolite at Kingham, near Chipping-Norton, and at Broadwell, near Merke-in-the-Marsh, Gloucestershire. But the formation in which the remains of the Megalosaur occur, in quantity only inferior to those in the Stonesfield slate, is the Wealden strata. Dr. Mantell discovered in the ferruginous clay of the Forest of Tilgate a fine vertebra, and a portion of the femur of the Megalosaurus, 22 inches in circumference. Some fragments of the metacarpus and metatarsus from this locality, were thicker than those of a large hippopotamus. Many teeth, of the same form as those found by Dr. Buckland, at Stonesfield, have been obtained from Wealden strata. Mr. Holmes, surgeon, at Horsham, possesses a good caudal vertebra, and some other parts of the Megalosaurus from the furruginous sand near Cuckfield, in Sussex. The magnificent specimen of dorsal vertebræ, T. xix, *loc. cit.*, was discovered by Mr. Beckles, F.G.S., in the Wealden formation near Battle. Remains of the Megalosaurus occur in the Purbeck Limestone at Swanage Bay. In some of the private collections in the town in Malton, Yorkshire, are teeth, unquestionably belonging to the same species as the Stonesfield Megalosaurus, from the Oolite in the neighbourhood of that town.

TAB. I.

Sacrum of the Megalosaurus; half nat. size.

From the Oolitic Slate of Stonesfield, Oxfordshire. In the Geological Museum, Oxford.

T. I.

5

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TAB. II.

Portion of the sacrum of the Megalosaurus; nat. size.

From the Wealden, of Tilgate, Sussex. In the British Museum.

T.II.

TAB. III.

Fig. 1. Under surface of the portion of the sacrum of the **Megalosaurus ;** nat. size.

,, 2. End-view of the body of a sacral vertebra of the **Megalosaurus ;** nat. size.

From the Wealden, of Tilgate, Sussex. In the British Museum.

TAB. IV.

Megalosaurus Bucklandi; one fourth nat. size.

Fig. 1. Cervical, or anterior dorsal, rib.

" 2. A succeeding dorsal rib: *c*, upper view of the head and neck.

" 3. A posterior dorsal rib of a larger individual.

" 4. The right clavicle.

" 5. The right ischium.

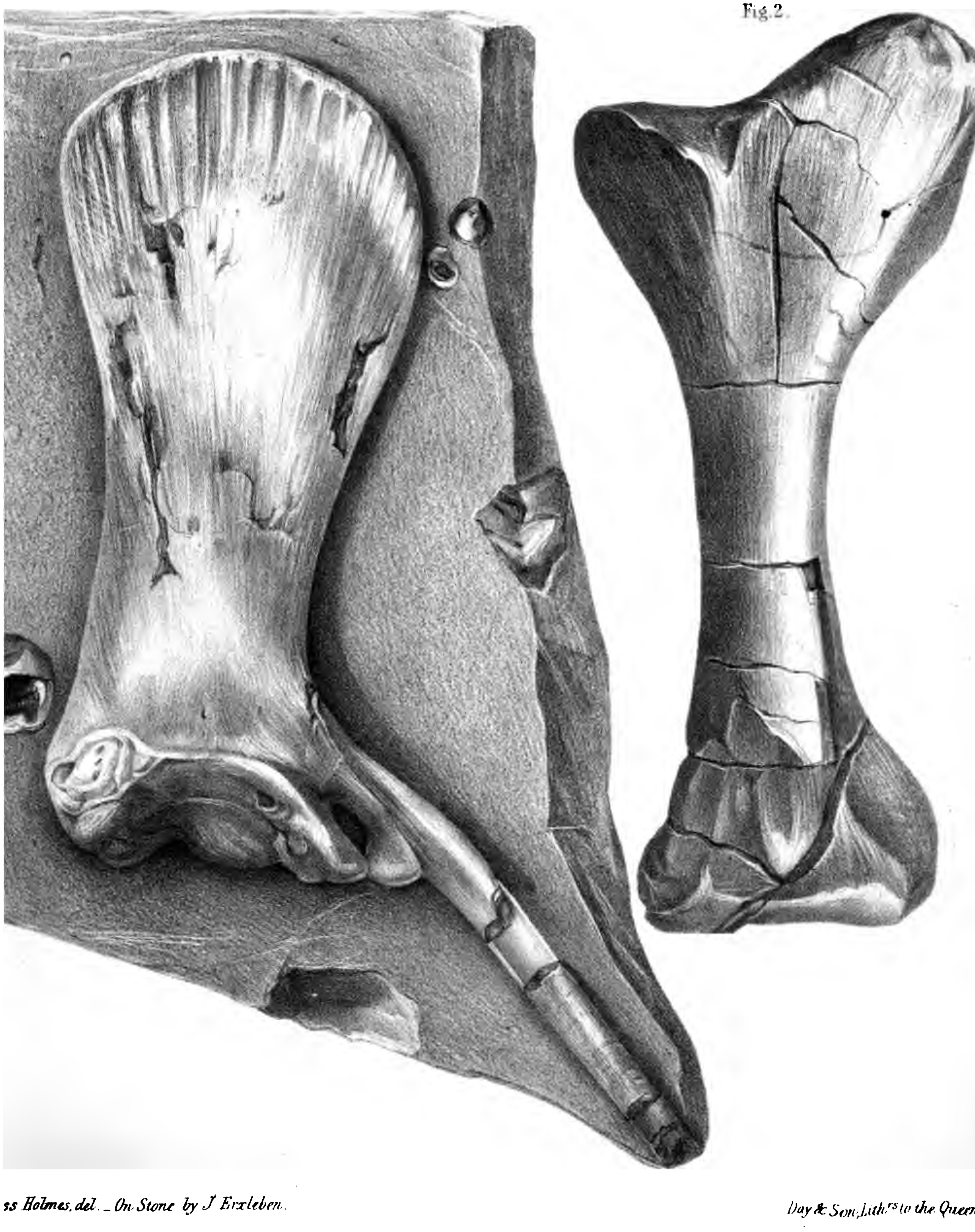
TAB. V.

The scapula of the Megalosaurus (?); one fourth nat. size.

From the Wealden, of Sussex. In the Museum of J. B. Holmes, Esq., of Horsham.

Fig.1. T.V.

Fig.2.



ss Holmes, del. _ On Stone by J. Erxleben. Day & Son, Lith.rs to the Queen.

TAB. VI.

The coracoid of the Megalosaurus; one fourth nat. size.

Fig. 1. Inner surface.
„ 2. Articular border.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

e on Stone by J. Erxleben.

Day & Son Lith^rs to The Queen

TAB. VII.

The femur of the Megalosaurus ; one fourth nat size.

Fig. 1. Hinder surface.
 „ 2. Inner surface.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

TAB. VIII.

Femoral condyles of the Megalosaurus; nat. size.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

T. VIII.

From Nature on Stone by J. Erxleben.

Day & Son, Lithrs to The Queen.

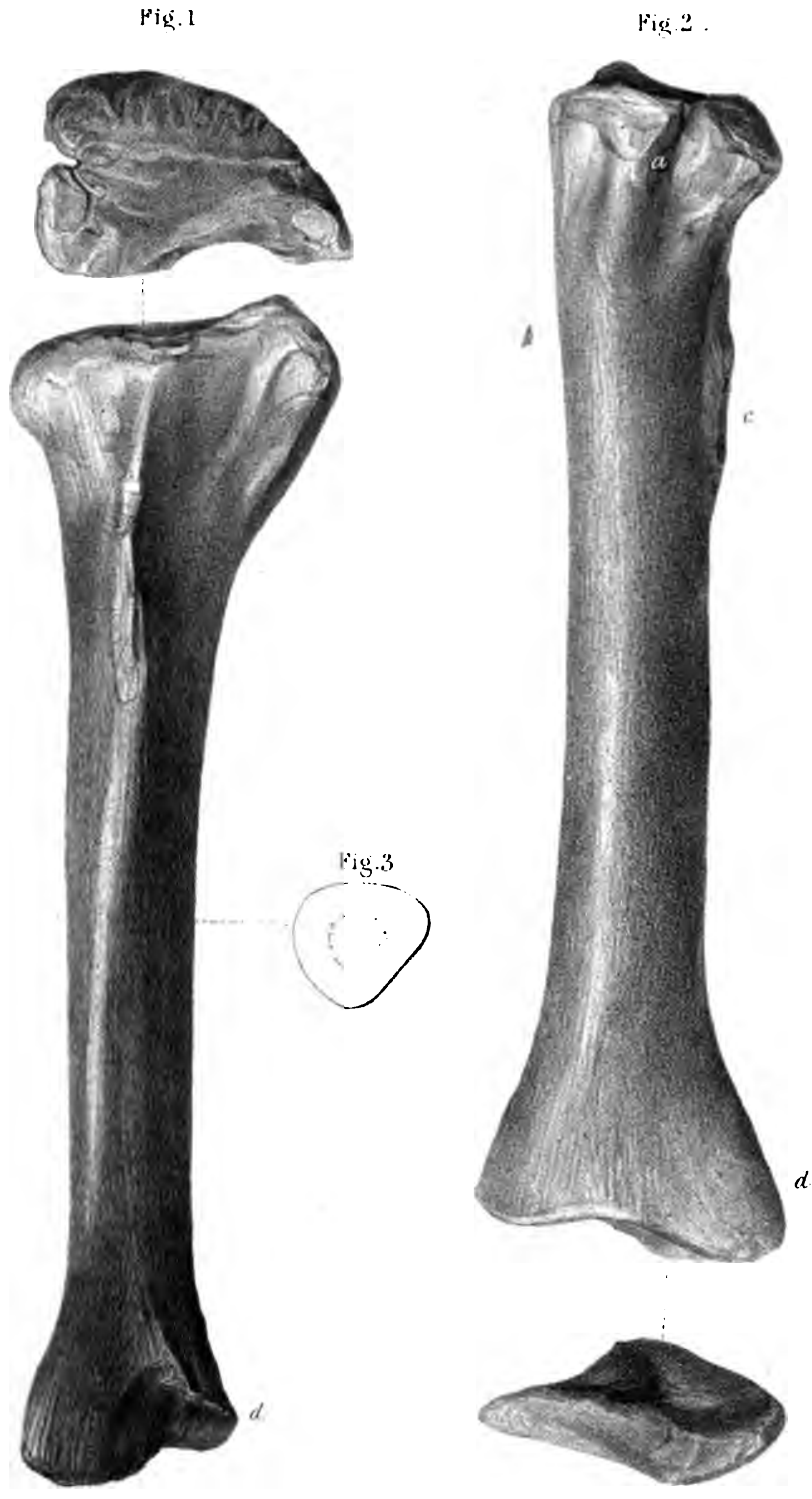
TAB. IX.

The tibia of the ***Megalosaurus***; one fourth nat. size.

Fig. 1. Outer surface, with the upper articular end.
,, 2. Hinder surface, with the lower articular end.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

T. IX.



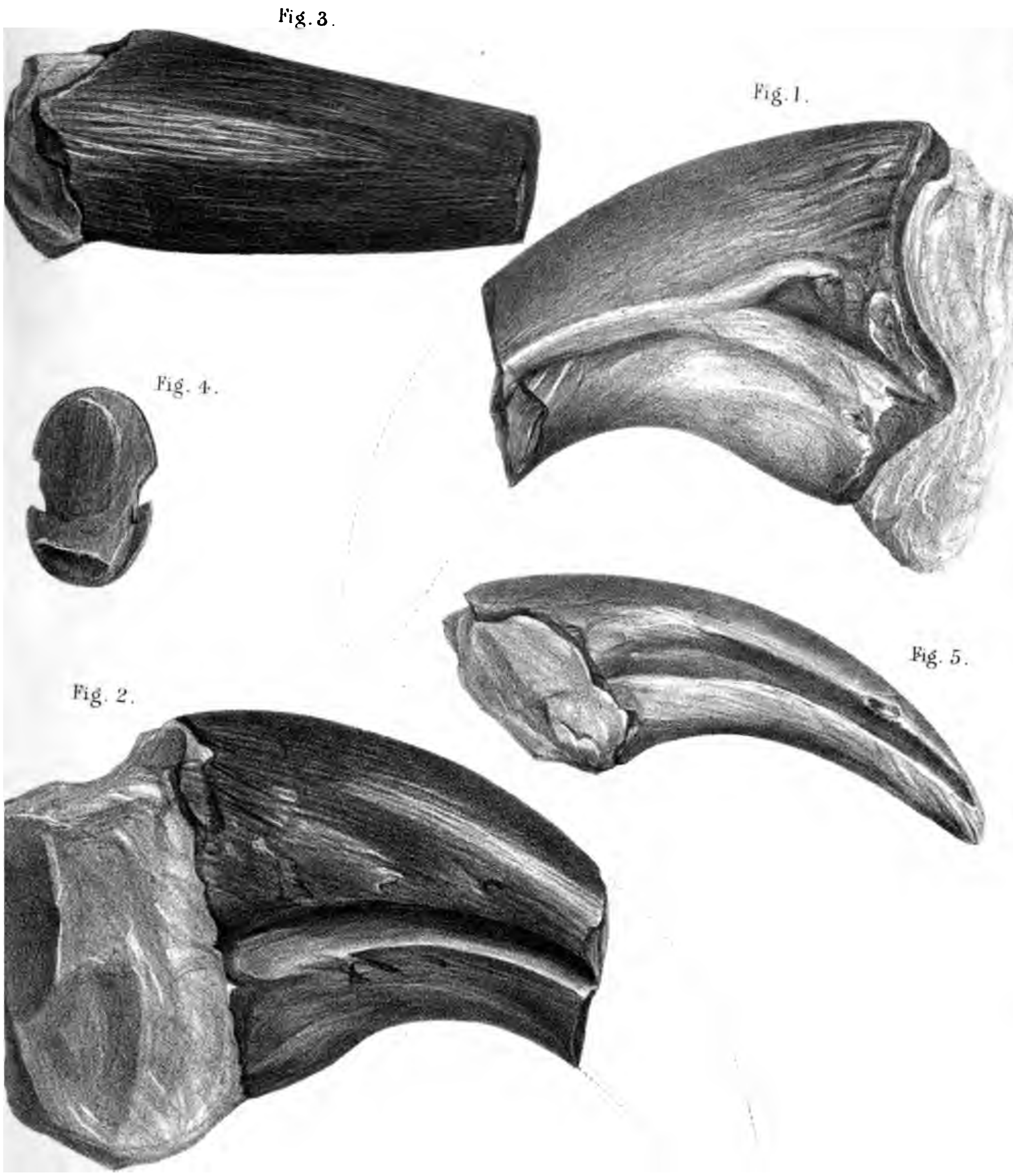
TAB. X.

Ungual phalanges of Megalosaurus (?); nat. size.

Fig. 1. Inside view.
,, 2. Outside view.
,, 3. Upper surface.
,, 4. The fractured end of figs. 1 and 2.
,, 5. Side view of a smaller entire phalanx.

From the Wealden Sand, Tilgate, Sussex. In the British Museum.

T. X.



lature on Stone by J. Erxleben.

Day & Son Lithrs to the Queen

TAB. XI.

Megalosaurus Bucklandi, nat. size.

Fig. 1. Inside view of a portion of the dentary element of the mandible, with teeth.

„ 2. Outside view of part of ditto.

„ 3—11. Various teeth, the last much worn.

„ 12. Magnified view of the finely serrated border of the teeth.

Figs. 4, 7, and 9 from the Wealden, of Sussex; fig. 5 from the Cornbrash, of Oxfordshire; fig. 7 from the Bath Oolite, Somersetshire; the rest from the Oolitic Slate, of Stonesfield, Oxfordshire.

All the specimens, save fig. 1, in the Oxford Museum, are in the British Museum.

TAB. XII.

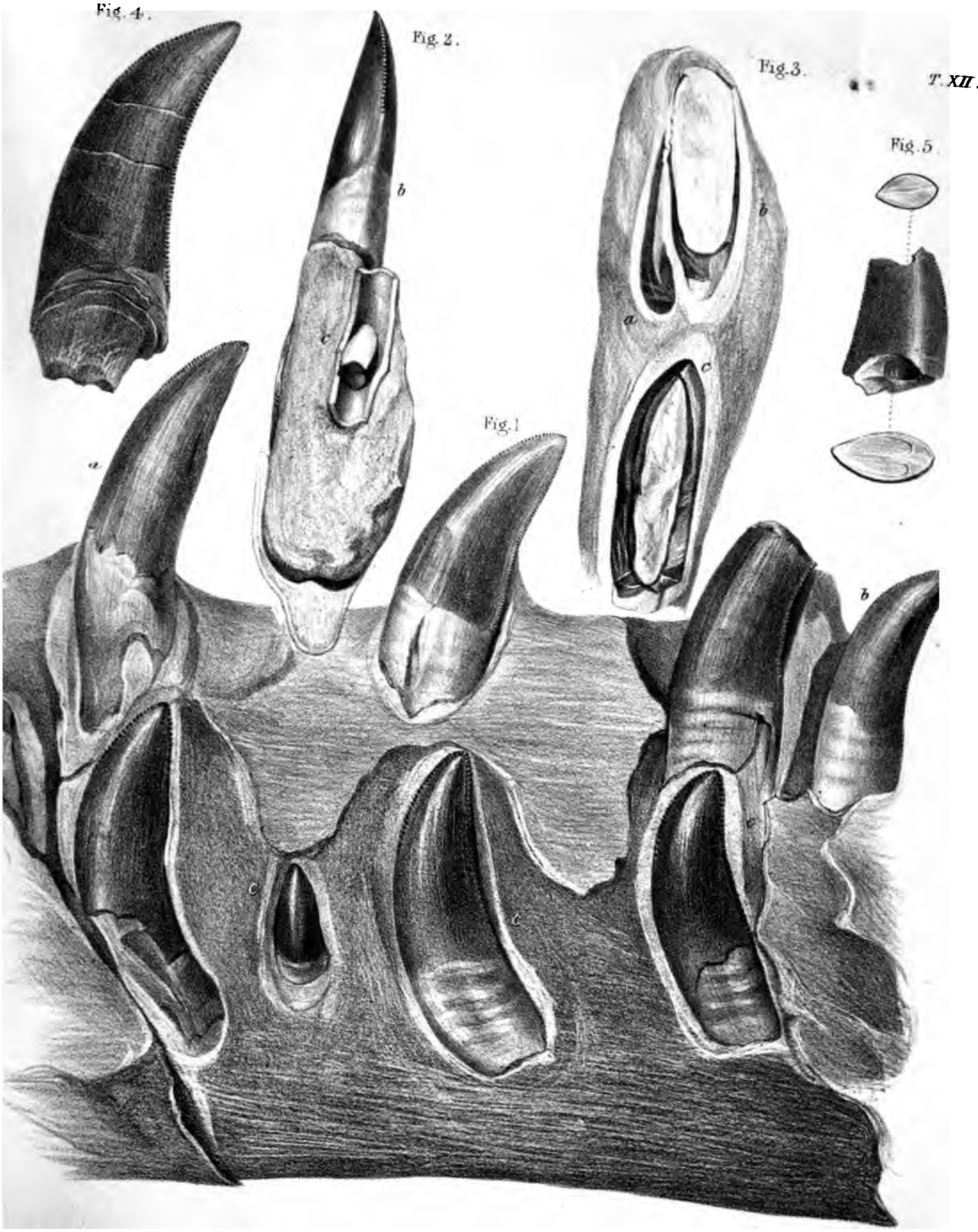
Figs. 1—3. A portion of the mandible with teeth of the *Megalosaurus Bucklandi;* nat. size.

Fig. 4. Side-view of a full-sized tooth of the Megalosaurus.

„ 5. A portion of a tooth of *Megalosaurus,* from the Inferior Oolite, of Selsly Hill, Gloucestershire. In the British Museum.

The foregoing figures are taken, with the permission of his Grace the Duke of Marlborough, from a specimen in his Grace's collection, from the Oolitic Slate, of Stonesfield, Oxfordshire.

T. XII.



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MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

PART IV.

PAGES 8—26; PLATES IV—XI.

DINOSAURIA (HYLÆOSAURUS).

[WEALDEN.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1858.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN FORMATIONS.

ORDER—*DINOSAURIA.*

Genus—HYLÆOSAURUS,* *Mantell.*

THE third well-marked genus of Dinosaurian Reptiles, referred to in a former Monograph,† is founded upon a large portion of the skeleton of one and the same individual (T. IV), to which the name at the head of this section has been applied by its discoverer, Dr. Mantell.

In assigning to this genus a place in the Dinosaurian order, I have been guided by the structure of the vertebral column, especially the sacrum (T. V and VI); and, in placing it after the Megalosaurus, by the following considerations. The distinct alveoli in the jaws of the Megalosaurus, and the resemblance of its teeth to those of two extinct Crocodilians, viz., the Argenton species and the Suchosaurus, seemed to claim for that great carnivorous Dinosaur a position higher, or nearer to the Crocodilian order. In the present genus, which there is good reason for believing to have resembled the Lizards more than the Crocodiles in its dental characters, an affinity to the *Crocodilia* is, however, manifested not only by the structure of the vertebræ and ribs common to it with other Dinosaurs, but likewise by the presence of dermal bones, or scutes, with which the external surface was studded.

The Hylæosaurus has not been made known, like the Megalosaurus, from detached parts of the skeleton successively discovered and analogically recomposed, but was

* ὑλαῖος, *sylvestris*, belonging to a wood, σαῦρος, lizard.

† Part iii, p. 1, Palæontographical Publications for 1856.

The lateral compression of the centrum increases in the sixth (8) and seventh (9) (conspicuous) vertebræ, in which the under surface forms an obtuse ridge; in the eighth vertebra (10) this surface is broader and more rounded. In none of these vertebræ is a process developed from the under surface, as in the hinder cervical and anterior dorsal vertebræ of the Crocodiles; and in none of them is the anterior articular surface of the centrum convex, as in the Streptospondylus.

The most striking character of the vertebræ of the Hylæosaurus is the great development of the neural arch and its processes. The anterior articular processes extend (in the anterior dorsal and cervical vertebræ) over half the centrum next in front, and a broad diapophysis (upper transverse process) is developed from the side of the neurapophysis and along its anterior continuation: the diapophysis extends horizontally outwards, is notched anteriorly, and contracts to an obtuse point, against which the tubercle of the rib articulates: it is flat transversely, slightly concave lengthwise, and smooth below. The diapophyses increase in length and strength as the vertebræ extend along the trunk; and the ribs, which they contribute to support, exhibit a still more rapid increase. The ribs present, as in the other Dinosaurs and Crocodiles, a bifurcated vertebral end, for the double articulation above described (T. IV, *pl* 3, and the ribs attached to 9 and 10). The rib (*pl* 2) which appears to be the second, and belongs to the cervical region, is short and pointed, not exceeding 4 inches in length. The neck and head of the rib corresponding with the seventh conspicuous vertebra, apparently the third free rib (*pl* 3), is 2 inches 2 lines in length; the tubercle, or upper head, is 10 lines long; the breadth of the rib at the point of bifurcation is 1 inch 1 line; the entire length of this rib is 5½ inches. The neck of the fourth rib (*pl* 4) has the same length as that of the third, but is twice as thick and strong; the tubercle is broader but shorter. Beyond the tubercle the shaft of the rib is bent at nearly right angles with the neck. This soon begins to shorten, and the shaft of the rib to lengthen, until it becomes attached solely to the diapophysis.

In the dorsal vertebræ the body increases in all its proportions, excepting its length. The lateral compression now manifests itself at the upper part of the centrum, just below the neurapophysial suture; the under surface of the posterior dorsal and lumbar vertebræ is convex transversely, but in a less degree than in the Megalosaurus, and in some it is obscurely carinated. The external surface at the middle contracted part of the vertebra is moderately smooth, but the minute striæ give it a somewhat silky lustre; it is longitudinally but irregularly ridged and grooved near the articular ends. These are both slightly concave at the centre, more slightly convex near the circumference.

The difference between the vertebræ of the Hylæosaur and the biconcave Crocodilian vertebræ is chiefly manifested in the development of the neural arch. The modification of this part in the cervical vertebræ has already been mentioned. In the dorsal vertebræ (T. VIII, fig. 10) each neurapophysis rises vertically, contracting in

the axis of the vertebra, expanding transversely or outwardly, until it has attained a height equal to that of the centrum; there it expands into a broad and flat platform (*d*), from the middle line of which the broad spine (*ns*) is developed. A vertically compressed but strong diapophysis (*d*) is developed from the side of the neurapophysis, and is supported by a pyramidal underprop (*t*), extending upwards and outwards from the anchylosed base of the neurapophysis. There is a large deep and smooth depression (*p*) on each side of the base of the diapophysis. The anterior surface of the neural arch, above the anterior oblique processes, or prezygapophyses (*z*), is traversed by a vertical ridge, on each side of which there is a shallow depression.* The spinous process (*ns*) is of unusual thickness; its transverse breadth at the base measures 1 inch: this modification may probably relate to the support of great dermal spines. The spinal canal in the dorsal vertebræ is cylindrical, and expanded at both extremities; its diameter at the middle is 7 lines, at the expanded outlets 10 lines, in a posterior dorsal or lumbar vertebra. Here the bases of the neurapophyses begin to shorten, and leave a small proportion of the upper surface of the centrum uncovered at both ends, chiefly at the posterior end.

The following are dimensions taken from three of the vertebræ in the portion of the skeleton of the Hylæosaurus (T. IV):

	Vertebra No. 4.		Vertebra No. 6.		Middle dorsal.	
	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of centrum . .	1	10	2	2	2	9
Vertical diameter of its articular end . .	0	0	1	6	2	6
Transverse diameter of its articular end . .	2	0	2	2	3	0
Transverse diameter of middle of centrum . .	0	0	0	0	2	0

The differences between the vertebræ of the Hylæosaurus and Megalosaurus have been already pointed out, and are further shown in the admeasurements given above. The vertebræ of the Hylæosaurus differ from those of the Iguanodon in their greater transverse diameter, and in the breadth of their under part; those of the Iguanodon are flatter vertically along their whole sides, which converge to a narrower ridge at the under part. The vertebræ of the Hylæosaurus differ from those of the Streptospondylus in the sub-biconcave character of the articular ends of the centrum, and in its comparative shortness and thickness. The separated neural arch might be distinguished from that of the Streptospondylus by the simplicity of the supporting buttress of the transverse process; and, although equal in height, yet is superior in the expansion and strength of the platform and spinous process. From the vertebræ of the Poikilopleuron, an oolitic Saurian of about the same bulk, those of the Hylæosaurus differ in their more compact osseous structure, and in the absence of the large cells that characterise that structure in the vertebral bodies of the Poikilopleuron.

* This description is taken from Nos. 2586 and 2125 parts of the same vertebra in the British Museum.

The Sacrum (T. V and VI).

There is a portion of a sacrum of a small or young Dinosaur (T. VI, figs. 1 and 2, No. $\frac{484}{2481}$, British Museum), which, in the form and proportions of the bodies of the vertebræ, most resembles the present genus, and cannot be referred to either the Megalosaurus or Iguanodon. It includes two entire and parts of two other vertebral bodies, anchylosed together, and to the bases of the neurapophyses, which, as in the Megalosaurus, are transferred to the upper and lateral parts of the interspaces of the subjacent bodies. These are moderately, but regularly, contracted in the middle and chiefly laterally, being more flattened below, where likewise each is traversed by a longitudinal sulcus. At the middle of each lateral concavity there is a vascular perforation. I am uncertain which is the anterior part of this interesting series; but, by the analogy of the Megalosaurus, conclude that vertebra which supports the greatest proportion of its neural arch to be posterior to the adjoining one which supports the remaining small proportion. On this basis also I assume that the anterior sacral vertebra is deficient, if we may allow five to the Hylæosaur as to the other Dinosaurs.

The second sacral vertebra, then, is here broken across the middle of the body, exposing its solid minutely cellular central structure: its neural arch is too mutilated for profitable description: its base rests nearly equally on the second and third sacral bodies. The third neural arch, which exhibits a similar relative position, has its base extended half way down the vertebral interspace; its strong transverse process, diapophysis and pleurapophysis combined, extends outwards and forwards, and is at first contracted, then expands both transversely and vertically, most so in the latter direction, and is twisted obliquely, so that the lower end is directed downwards and forwards, and the upper and thicker end is bent obliquely backwards, until it meets and becomes anchylosed to the anterior production of the transverse process of the next vertebra behind: an elliptical space is thus produced, the axis of which is nearly vertical, and into this space the neural canal opens; the nerve being transmitted over the middle of the body of the vertebra, as in the sacrum of the Megalosaurus and Iguanodon.

The upper and inner part of the base of the broad, oblique transverse process, or sacral rib, abuts against the base of the spinous process. There is no appearance of accessory spines or metapophyses, such as the sacrum of the Megalosaurus is complicated with.

The following are admeasurements of the present portion of the sacrum of the Hylæosaurus:

This increase is still more marked in the fourth sacral vertebra (fig. 4), which is also longitudinally, but more widely, channelled along its under surface.

The breadth, as compared with the length, increases in the fifth sacral vertebra (5), shown to be the last, as in the Iguanodon, by the terminal articular surface for the first caudal vertebra. Like the preceding centrums, that of the fifth sacral vertebra in the Hylæosaurus is relatively broader and flatter below than in the Iguanodon: but the lateral compression beneath the wide outlets for the nerves, usually intervertebral in position in other reptiles, is well marked. These outlets are relatively wider in the Hylæosaurus than in the Iguanodon, and probably indicate greater activity, and a swifter rate of motion, in the smaller herbivorous Dinosaur.

The base of the pleurapophysis or rib-element—taking the place and function of an inferior transverse process in the Dinosaurian sacrum—may be discerned, wedged into the interspace between the second and third sacral vertebræ at *pl* 3, and again between the third and fourth vertebræ, at *pl* 4, fig. 2, T. V.

A third portion of the sacrum of the Hylæosaurus, which escaped the cognizance of the authors of the paper in the 'Philosophical Transactions' for 1849, is the specimen No. 28,936, British Museum. This consists of the third sacral vertebra, with part of the second and fourth anchylosed therewith, a great proportion of the neural arch, and a small part of the left ilium being included in this very instructive specimen. It is from the submerged Wealden of the Isle of Wight, and has been subject, like many of the fossils from that locality, to a certain degree of attrition by sea-waves on the beach.

The pleurapophysis (fig. 3, *pl* 3), continued from the obliterated interspace between the third and second vertebræ, quickly assumes the form of a broad and high plate, compressed from before backwards, and again becoming thickened when it abuts against the ilium (62).

The diapophysis (fig. 4, *d* 3), arising from the side of the neural arch, seems to form the upper part of the same broad, vertical, transverse wall of bone; but the suture between the pleurapophysial and diapophysial elements of this wall is clearly traceable, extending from the base of the neurapophysis upwards and outwards. The diapophysis at its upper part expands, and seems to bifurcate or abut against the side of the base of the neural spine. This spine forms, at the part of the sacrum here described, a continuous ridge of bone.

The fractured outer border of the ilium has been rounded and water-worn to its present form, which must not be taken as indicating its natural one. A large vacuity was bounded by the ilium and the two contiguous diapophysial plates (fig. 3), as in the sacrum of the Iguanodon: the large nerve-outlet, formed by the receding borders of contiguous neural arches, and the middle part of the centrum, opens into the large space above defined.

I have not met with this character in the corresponding vertebræ of other Saurians. In the vertical direction the sides of the centrum in the posterior caudals converge at almost a right angle to the inferior groove. The greater breadth of the centrum, in proportion to its height, may still be discerned in the terminal caudal vertebræ (fig. 6): thus in the centrum 2 inches 2 lines long, the breadth was 1 inch 10 lines, and the height only 1 inch 3 lines. Here the bases of the short, but fore-and-aft extended, hæmapophyses appear to be confluent, as in fig. 7; but their peculiar shape would serve to distinguish them from a hæmal arch of an Iguanodon.

Bones of the Extremities.—Scapular arch.

The scapula of the Hylæosaurus (T. IV, 51) is longer and narrower than in the Monitors and Iguanas, adhering in this respect to the Crocodilian type, but most resembling in the shape of its blade or body, that of the genus Scincus. It differs, however, from the scapulæ of all known reptiles, and indicates an approach to the Mammalian type, by the production of a strong obtuse acromial ridge, separated by a deep and wide groove from the humeral and coracoid articular surfaces. The blade of the scapula is long, flattened, slightly convex on the inner and proportionally concave on the outer surface: the anterior margin is convex, the posterior one concave; the upper extremity or base truncate, slightly convex, with the posterior angle a little produced, the anterior angle rounded off. On the outer side of the scapula two broad convex ridges descend and converge to form the beginning of a thick and strong spine, at fourteen inches distance from the base; this then expands into the thick acromial ridge, which extends transversely, and is continued forwards as a long subprismatic process from the anterior angle of the head of the scapula. This process, the homologue of which exists in the scapula of the Iguanodon, and more developed in that of the Megalosaurus, is broken off in the present specimen about four inches from the neck of the scapula, with which it forms a right angle. The acromion is perforated at the base of its anterior prolongation by a foramen analogous to the supraspinal one in the scapula of the Edentate Mammalia. Besides the scapulæ preserved in the connected part of the skeleton, there is, in the Mantellian Museum, a nearly entire and detached scapula of larger size, discovered, in connection with many other bones of the skeleton, in a layer of blue clay near Bolney, in Sussex, and indicating the connected part of the skeleton first discovered in 1832 to have belonged to an immature individual. The dimensions of this scapula are as follows:

border (*f*), which shows a broad and shallow articular depression for the distal end of the fibula. The distal articular surface for the tarsus presents the same form of an oblique, wide, and shallow notch (*e*), as in the Megalosaurus.

The largest diameter of this end of the bone is 7 inches; the circumference of the middle of the shaft is 7 inches. At the back part of the shaft, five inches from the proximal end, is the orifice of a canal for the medullary artery, which passes obliquely downwards. The entire length of the bone is 16 inches.

Metapodium of the Hylæosaurus. T. XI.

The specimen, No. 2556, in the British Museum, figured in T. XI, exhibits three metacarpal or metatarsal bones of the same foot, cemented, as naturally connected, by the Wealden matrix. The shape of the outer (IV) and inner (II) of these bones indicates that three alone constituted their segment of the foot, unless some styliform rudiment may have existed, which has left no mark of junction with the next fully developed metapodial* bone.

Those bones of the foot of the Iguanodon, described in a former part of the present Monograph, and figured in T. I, II, and III, afford a means of comparison with the present specimen, and show that it cannot belong to the corresponding foot of the Iguanodon, and that it is very improbable that it can belong to another (fore or hind) foot of the same species. It plainly indicates a foot of longer and more slender proportions, with a different configuration of the metapodial bones. The relative lengths of these bones show that they belong to a foot of the same side of the body as that of the Iguanodon above described.

The proximal ends of the three bones have been broken off obliquely, the outermost (T. XI, II) retaining the greatest proportion of the shaft: the innermost (ib., IV) retains its distal articular surface; the middle bone (ib., III) has a portion of the same surface. The distal end of the outermost bone is broken away.

By the analogy of the metapodium of the Iguanodon, the innermost metapodial of the present specimen answers to the second in the pentadactyle foot, the middle to the third, and the outermost to the fourth. The foot to which they belonged was functionally tridactyle, through the arrest of development or suppression of the first and fifth toes in the pentadactyle foot.

The metapodial (II) has a sub-compressed shaft, convex on the inner or free side (figs. 1 and 2), slightly concave towards the middle metapodial; with the anterior

* The term "metapodium" signifies the same segment in both fore- and hind-feet, and is requisite in treating of such segment when it cannot be determined whether it is of the fore-foot, metacarpus, or of the hind-foot, metatarsus.

and at the part where the inner wall has been least mutilated, it nearly completes the socket, and incloses the long and slender fang of the tooth. Whence, I conclude, that the entire jaw of the extinct reptile would have exhibited a series of true sockets, with oblique outlets, not depressions merely, as in the present mutilated fragment; and that it would have agreed with the Megalosaurus in presenting the sub-thecodont mode of implantation of the teeth.

The crowns of all the teeth are broken off; the small sockets of reserve, exposed at the inner side of the base of the old sockets, do not contain any evidence of the species to which this fossil has belonged.

In my 'Odontography,'* I adopted the opinion of Dr. Mantell† respecting the present fossil, viz., that it belonged to a young Iguanodon; but subsequent considerations‡ induced me to refer it to the same species of extinct reptile as the teeth (T. VIII, figs. 6—9) belonged to.

Since the publication of my 'Reports on British Fossil Mammalia,' the lower jaw of the Iguanodon has been discovered, and leaves no room for doubt as to the generic and specific distinction of the present fossil. In the portion of jaw in question (T. VIII, figs. 2 and 3) there are eighteen alveoli in an extent of three inches: in the lower jaw of a young Iguanodon of the same size, there are but nine alveoli in the same longitudinal extent; whilst in three inches of the dentary border of the mandible of an older Iguanodon, there are but four alveoli. The form of the alveoli, as I had inferred from the known shape of the teeth of the Iguanodon, differs from that of the alveoli in the portion of jaw figured in T. VIII; but those alveoli accord with the shape of the fangs of the teeth next to be described.

* Part II, 1839, p. 248.

† 'Wonders of Geology,' vol. i, p. 393.

‡ "In the absence of this characteristic part of the tooth, an element in guiding our choice between the Iguanodon and Hylæosaur is given by the breadth of the interspaces of the sockets; these must bear relation to the breadth of the crowns of the teeth, if we suppose that they were in contact throughout the series, as in Lacertians. Now, the teeth of the Iguanodon, and those which I have referred to the Hylæosaur, differ in a marked degree in the breadth of the crown. The complicated and expanded crown of the Iguanodon's tooth is supported on a narrower stem; and the stems or fangs, if the crowns were in contact without overlapping, must have been separated by interspaces of proportional breadth, viz., twice their own breadth; but the thickness of the crown of the tooth of the Iguanodon renders it very unlikely that they did overlap each other. Now, the crowns of the teeth of the Hylæosaur are expanded to such an extent as, if in contact, to require an interspace of the fangs, not broader than the fangs themselves; and the interspaces of the fangs in the fragment of jaw under consideration correspond with crowns of this breadth. The fangs of the teeth in the Iguanodon are conical, and more or less angular; in the teeth presumed to belong to the Hylæosaur the fangs are cylindrical; the sockets in the present fragment correspond with the latter form." (Report on British Fossil Reptilia, in the 'Reports of British Association,' 1841, p. 110.)

Teeth of the Hylæosaur? T. VIII, figs. 6—9.

At the period of preparing my 'Report on British Fossil Reptiles,' the teeth of the Hylæosaurus were unknown; but in the quarries where the bones of that reptile had been discovered, a few teeth had been met with of a peculiar form, respecting which Dr. Mantell wrote—"They appear to have belonged to a reptile, and are entirely distinct from those of the Megalosaurus, Iguanodon, Crocodile, and Plesiosaurus, whose remains occur in the Tilgate strata."* The form and structure of these teeth (T. VIII, figs. 6, 7, and 8) deviate too much from those of the Crocodilian family to make at all probable a reference of them to the genera Poikilopleuron, Streptospondylus, or Cetiosaurus, which are much more closely allied to the Crocodilians than is the *Hylæosaurus*. In a later work,† Dr. Mantell attributes these teeth, on the authority of M. Boué, to the Cylindricodon, a name by which Dr. Jäger distinguishes one of the species of his genus "Phytosaurus." I have been favoured by Dr. Jäger with one of the bodies supposed to be the teeth of the Cylindricodon of the Wirtemberg Keuper, but it is merely the cast of a cylindrical cavity, consisting entirely of that mineral substance, without a trace of dental structure. The difference of form between the Wealden teeth now under consideration, and those on which the *Phytosaurus cylindricodon* of Jäger was founded, is pointed out in detail in my 'Odontography,'‡ and has been likewise appreciated by the estimable palæontologist, M. Fischer de Waldheim, by whom their resemblance to certain Saurian teeth from the Ural Mountains, belonging to the genus Rhopalodon, is indicated. From these teeth, however, the presumed Hylæosaurian teeth differ in having thick and flat instead of serrated coronal margins.

The fang of the tooth is subcylindrical, subelongate, smooth; as it approaches the crown it diminishes in one diameter, and slightly and gradually expands in the opposite diameter, forming a sub-compressed, slightly incurved crown, with the borders straight and converging at a moderately acute angle to the apex. These borders, in most specimens, are more or less worn, indicating the teeth of the opposite jaws to have been placed alternately, so as to meet and reciprocally occupy the angular vacuities left by the sloping borders of the crown: the enamel at these borders being worn away, and the dentine exposed.

The following is the result of a microscopical examination of these teeth. The tooth consists of a body of dentine covered by a thick coating of clear enamel, with minute superficial longitudinal striæ, and surrounding a small central column of osteo-

* 'Wonders of Geology,' vol. i, p. 403.

† 'Geology of the South-east of England,' p. 293.

‡ P. 196.

dentine, consisting of the calcified remains of the pulp. The dentine differs, like that of existing Lacertians, from the dentine of the Iguanodon in the entire absence of the numerous medullary canals which form so striking a characteristic of the more gigantic Wealden reptile. The main dentinal tubes are characterised by the slight degree of their primary inflections; they are continued in an unusually direct course from the pulp-cavity to the outer surface of the dentine, at nearly right angles with that surface, but slightly inclined towards the expanded summit of the tooth. They are chiefly remarkable for the large relative size of their secondary branches, which diverge from the trunks in irregular and broken curves, the concavity being always towards the pulp-cavity. In most parts of the tooth, the number of these branches obscures even the thinnest sections.

The ossified pulp exhibits the parallel concentric layers of the ossified matter surrounding slender medullary canals, and interspersed with irregular elliptical radiated cells, affording the usual characters of the texture of the bone in the higher reptiles.

From the form and structure of these teeth, it may be inferred that they have belonged to a Dinosaurian reptile; not so strictly phytiphagous as in the Iguanodon, but probably having a mixed diet.

In reference to the size of both the fragment of jaw and of the teeth, there is about the same proportion between them and the known remains of the Hylæosaurus, as between the jaw with teeth of the Iguanodon and the vertebræ and limb-bones of that colossal Dinosaur. The structure of the osseous substance of the portion of jaw figured in T. VIII closely accords with that of the known bones of the Hylæosaurus.

Having, therefore, demonstrated that the above-described mandibular and dental fossils of the Wealden do not appertain to the Iguanodon, nor to the Cylindricodon, it has appeared to me more to the interests of palæontology to refrain from adding to its catalogues a new name, which at present could signify nothing but the bare possibility that the grounds for approximating the fossils in question to the Hylæosaurus may prove not to be valid.

Dermal Scutes. T. X.

Unequivocal evidence that a dermal skeleton, analogous to that in the recent Crocodiles, was developed in the Hylæosaurus, has been afforded by the discovery of bony scutes in the mass of petrified vegetable matter removed in clearing the portion of the skeleton first described. Some of these detached bony plates still adhere to the caudal vertebræ, and may be observed to decrease in size as they approach the end of the tail (T. X, fig. 1, *i*, *i*). From their form, which is elliptical or circular, and from the

Lizard. The chief objection, though not decisive, against this view is, a want of symmetry in the form of the most perfect of them. They are nearly flat, but along the middle present a slight degree of concavity towards the observer, which, however, I once thought "might be paralleled by a similar concavity on the oposite side buried in the stone;"* but a separate specimen since obtained proves that side to have been convex (T. IX, fig. 3); and the anterior margin in the bones (*d*, *d*, T. IV) inclines from the middle line towards the concave side.

With regard to their relative position to the rest of the skeleton, it must be remembered that the ventral surface of this is exposed (T. IV); so that the under parts of the bodies of the vertebræ are towards the observer, and their spines imbedded in the matrix. The coracoids (52) and scapulæ (51) are placed, as might be expected in a skeleton little disturbed and lying on its back, with their under surfaces towards the observer, and covering, like a buckler, a portion of the vertebræ and ribs. In this position we might look for a portion of the apparatus of the sternal or abdominal ribs, in the hope of discerning the modifications of these variable parts which might characterise a genus differing in many peculiarities from other known Saurians. Now it is with the apparatus of abdominal ribs, which present such a diversity of characters in other Saurians, that it may be useful to compare the long flattened bones in question, as well as with the supporting bones of a dorsal crest, in the event of a future discovery of a skeleton or portion of skeleton of the Hylæosaurus including these bones. The objection to their being abdominal ribs, which may be founded on their great relative breadth as compared with those ribs in other Saurians, and especially with the vertebral ribs of the Hylæosaurus itself, deserves due consideration; but the same objection applies to the bones in question as compared with the superadded spines in the Lizard with a dorsal fringe, or with the spines of the vertebræ themselves in the Hylæosaurus. For the dorsal dermal spines in the Cycluar correspond in number with the spines of the vertebræ which support them, while the base of each of the hypothetical dermal spines of the Hylæosaur extends over more than two vertebræ.

In the Monotrematous quadrupeds (*Ornithorhynchus* and *Echidna*) the abdominal ribs are as much broader than the vertebral ribs as they would be in the Hylæosaurus, on the costal hypothesis of the detached bony plates here suggested; and, after the close repetition in the Ichthyosaurus, of another of the remarkable deviations in those aberrant Mammals from the osteological type of their class, viz., in the structure of their sternal and scapular arch, the reappearance of the monotrematous modification of the sternal ribs in the present extinct reptile would not be surprising. The want of symmetry and the difference of size and form, above alluded to, in the four succeeding spine-shaped plates, agree better with the costal than the spinous hypothesis.

* 'Reports of British Association,' 1841, p. 116.

other, and the unsymmetrical form must have related to such unusual disposition. In the *Xiphosurus velifer* of Cuvier, the fin-like crest along the dorsal aspect of the tail is supported by osseous spines: in the *Lophura* a dorsal crest is similarly supported; but the dermal spines are symmetrical. There remains the hypothesis, that there may have been two series of such spines, projecting one from each side of the dorsal region of the Hylæosaurus.

The shortness of the tibia, and the unusual development of its terminal processes for muscular attachments, indicate great strength of the hind limbs; and the glimpses which we thus obtain of this Wealden Dinosaur convey most strange ideas of its form and habits.

The remains of *Hylæosaurus armatus* have been discovered in the Wealden formation at Battle, Bolney, and Tilgate Forest, Sussex.

TAB. IV.

Portion of the skeleton of the Hylæosaurus, one fourth nat. size.

From the Wealden of Tilgate, Sussex. In the British Museum.

TAB. V.

Four anchylosed bodies of sacral vertebræ of a young Hylæosaurus, nat size.

Fig.
1. Oblique side view, showing the expanded neural canal.
2. Under view.

From the Wealden of Tilgate Forest, Sussex. In the Collection of
Captain Lambart Brickenden, F.G.S.

T.

Fig. 1.

Fig. 2.

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TAB. VI.

Portions of the sacrum of the Hylæosaurus, half nat. size.

Fig.

1. Under view of the third and fourth, with portions of contiguous anchylosed, sacral vertebræ.

   From the Wealden of Tilgate, Sussex. In the British Museum.

2. Side view.
3. Under view.
4. Upper view of the third, with portions of the second and fourth, sacral vertebræ.

   From the submerged Wealden Beds, South Coast, Isle of Wight. In the British Museum.

1

2

3

4

... Nature on Stone by J Erxleben

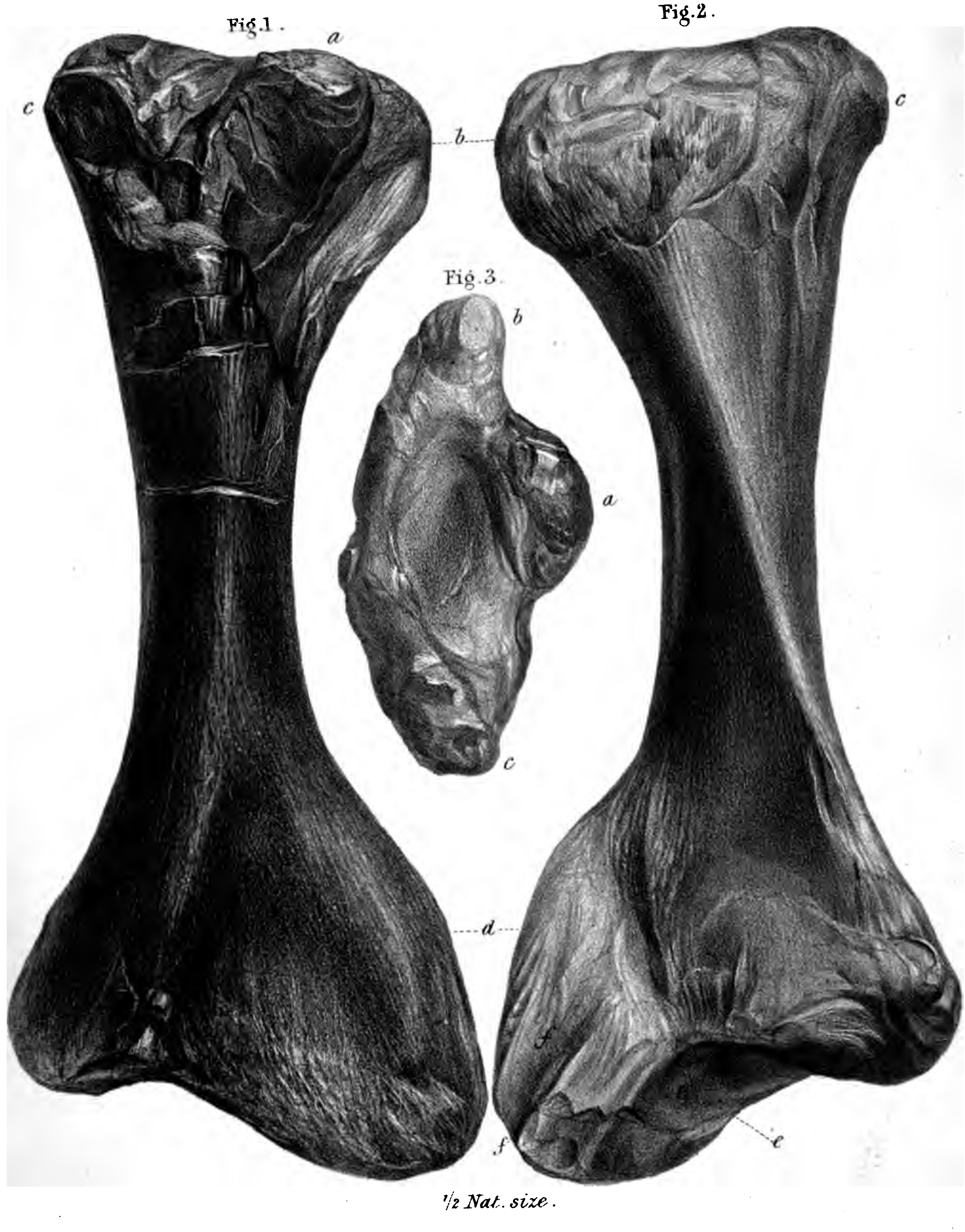
Day & Son Lith^rs to The Queen

TAB. VII.

Tibia of the Hylæosaurus, half nat. size.

Fig.
1. Inner side view.
2. Outer side view.
3. Upper articular end.

From the Wealden at Bolney, Sussex. In the British Museum.



½ Nat. size.

TAB. VIII.

Fig.

1. Outside of a portion of jaw.
2. Inside of the same portion of jaw.
3. Upper view of the same.
4. The hinder fractured end of the same.
5. The fore fractured end of the same.

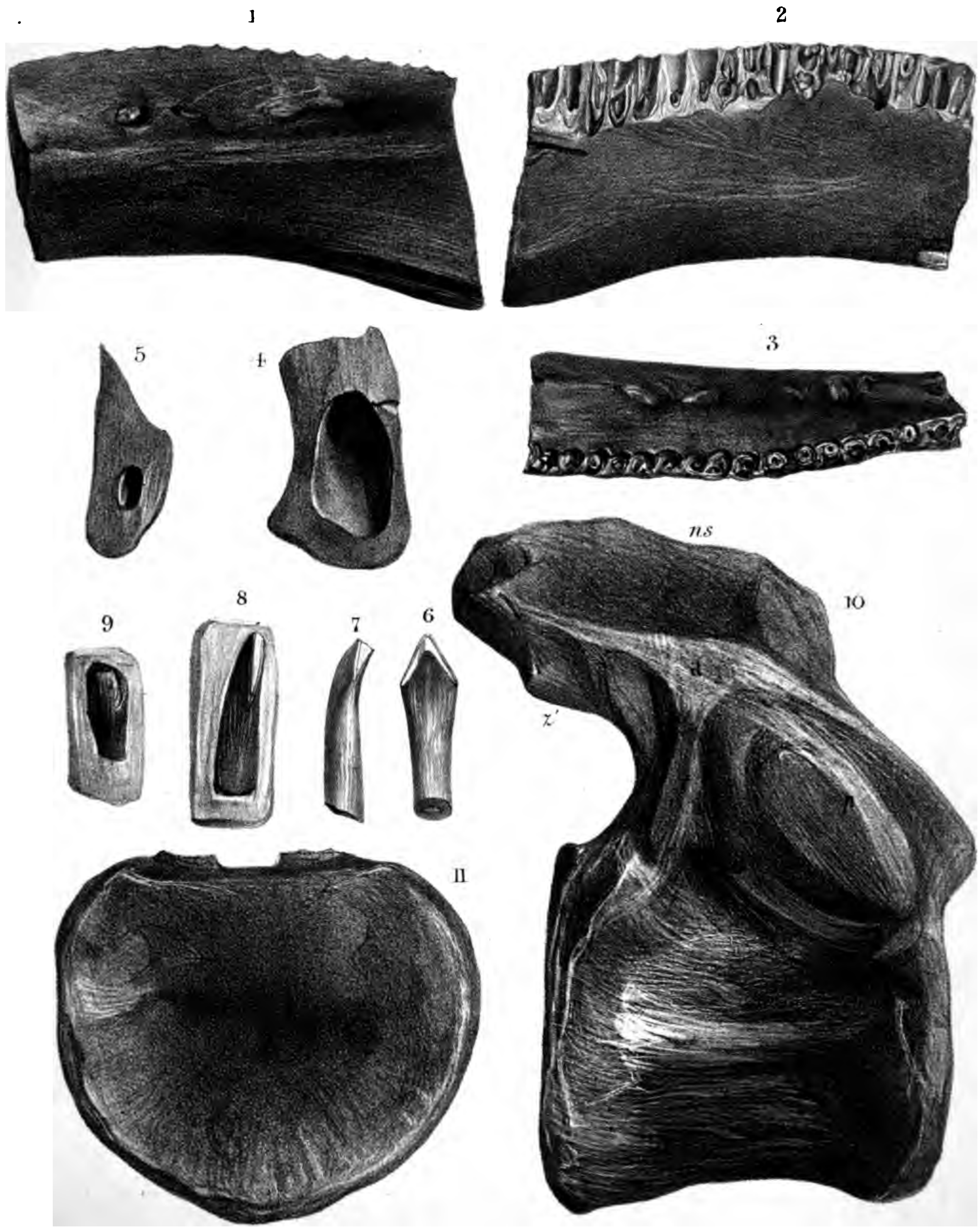
6 and 7. Two views of a tooth.

8. Side view of a tooth, imbedded in Wealden matrix.
9. A portion of a tooth, similarly imbedded.

The above specimens are referred, with probability, to the Hylæosaurus.

10. Side view of a dorsal vertebra of the Hylæosaurus.
11. Articular surface of the body of the same vertebra.

From the Wealden of Tilgate Forest, Sussex. In the British Museum.



From Nature on Stone by

TAB. IX.

The osseous basis of a dermo-neural spine of the Hylæosaurus.

Fig.

1. A section, highly magnified, of the osseous tissue.
2. Hinder border of the spine (reversed).
3. Side view of the spine.

From the Wealden of Tilgate Forest, Sussex. In the British Museum.

Fig. 1.

Fig. 2.

Fig. 3.

TAB. X.

Caudal vertebræ of the Hylæosaurus, one sixth nat. size.

Fig.

1. Ten vertebræ from the base of the tail.
2. Eleven vertebræ from near the end of the tail.
3. Under view of anterior caudal vertebræ, showing the form, and place of articulation, of the hæmapophyses.
4. Back view of a hæmal arch from the same (*h*) region of the tail (half nat. size).

4′. Under view of middle caudal vertebræ, showing the shape of the hæmapophyses, *h*.

5. Side view of a hæmal arch from a middle caudal vertebra (half nat. size).
6. Under view of caudal vertebræ beyond the middle of the tail.
7. Back view of a hæmal arch from one of these vertebræ (half nat. size).

The further modification of the hæmapophyses in the posterior caudal vertebræ is shown in fig. 2.

From the Wealden of Tilgate, Sussex. In the British Museum.

Fig. 1.

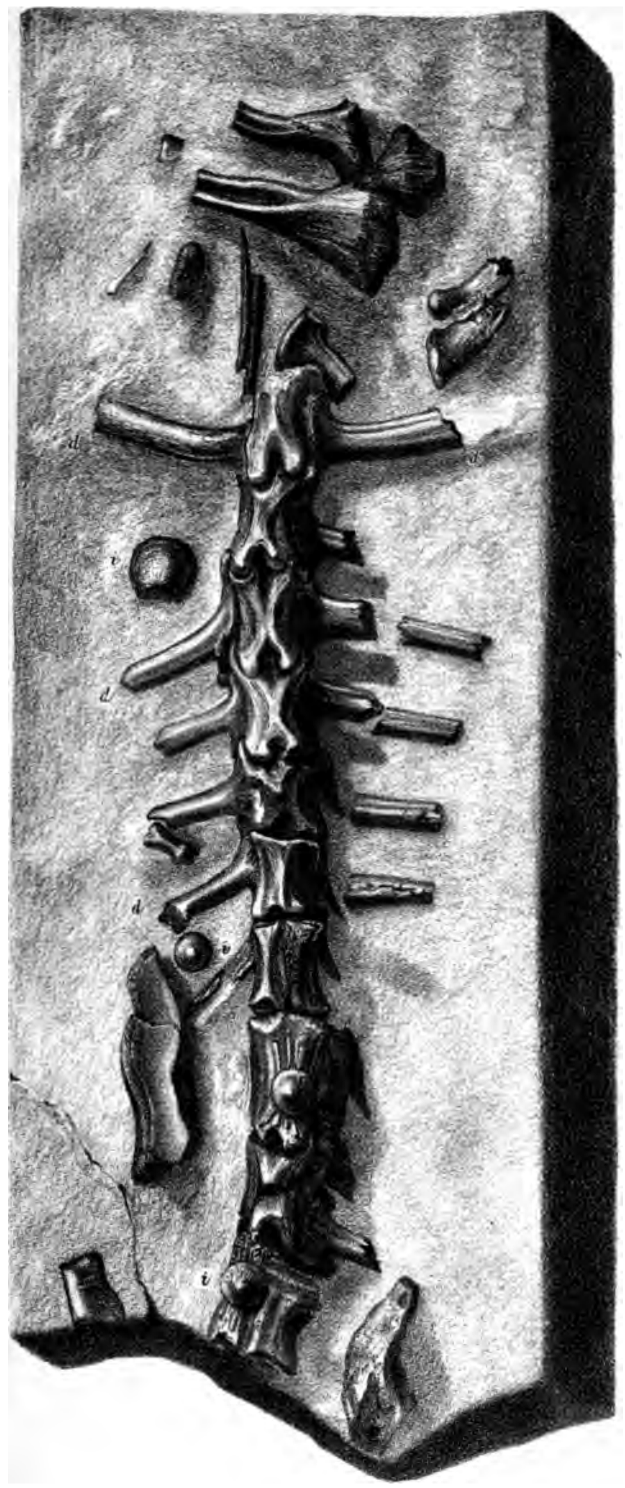


Fig. 2

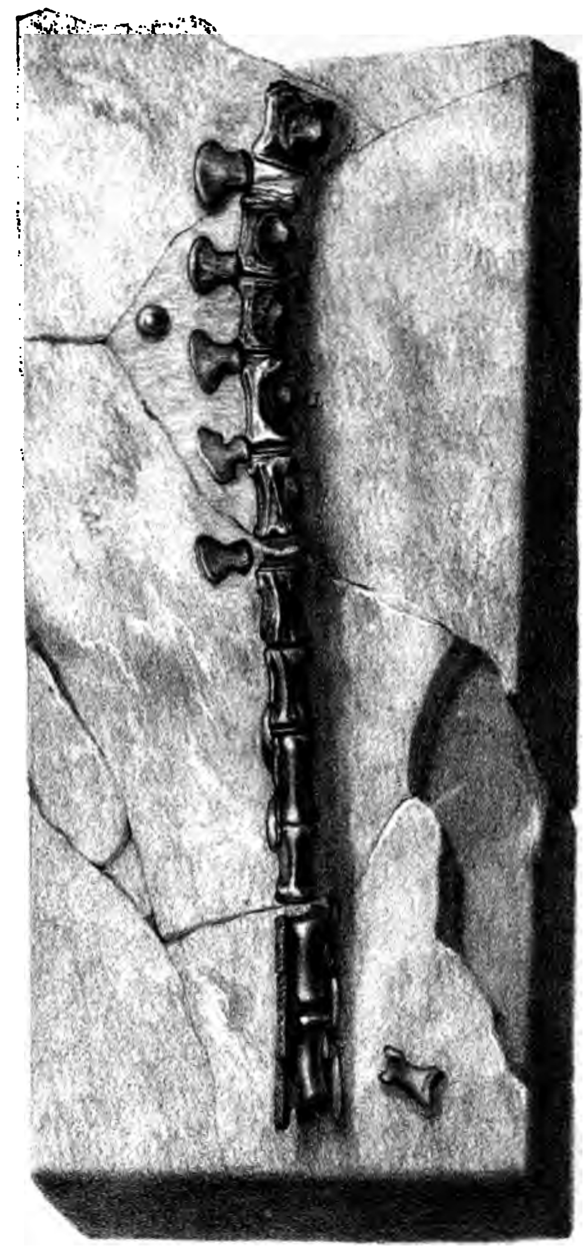


Fig. 5

Fig. 7

Fig. 6.

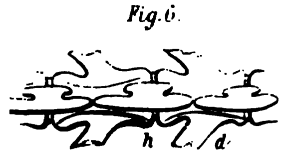


Fig. 4

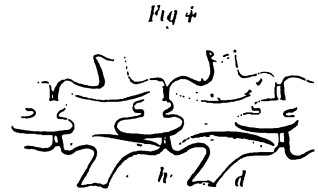


Fig. 4.

Fig. 3.

TAB. XI.

Metapodium of a foot of the Hylæosaurus.

Fig.

1. Front or upper view of the three normally developed metapodials.
2. Tibial side view of the innermost, answering to the second.
3. Fibular side view of the outermost, answering to the fourth.

From the Wealden of Tilgate, Sussex. In the British Museum.

T. XI

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

PART V.

PAGES 31—39; PLATE VIII.

LACERTILIA (NUTHETES, &c.)

[PURBECK.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1861.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

ORDER—*LACERTILIA*.

Genus—NUTHETES,* *Owen*.

NUTHETES DESTRUCTOR, *Owen*.

FOR a knowledge of the fossil remains on which the present genus and species were founded,† I am indebted to Charles Wilcox, Esq., M.R.C.S., of Swanage, Dorsetshire, by whom the specimens submitted to me, including a portion of jaw with teeth, were discovered in the Purbeck formation, from the bed marked *k* 93 in Mr. Austen's 'Guide.'‡

The teeth are attached by partial anchylosis to depressions on the inner side of an alveolar wall, or according to the "pleurodont type." Their enamelled crowns are moderately long, compressed, pointed, slightly recurved, with a well-marked but finely serrated margin before and behind; the thickest part of the crown is not at the middle, but nearer the anterior border, as in the great Varanus (*Var. crocodilinus*) and in *Megalosaurus;* and they clearly resemble, in

* Abbreviated from νουθέτητης, *Monitor;* in reference to the resemblance of the teeth of the fossil to those of the modern Varanian Monitors.

† 'Quarterly Journal of the Geological Society,' 1854, p. 120.

‡ 'Guide to the Geology of the Isle of Purbeck,' by the Rev. J. Austen, M.A., Blandford, 1852.

miniature, the teeth of that great carnivorous reptile. To the question whether these Purbeck fossils might not be of a fœtus or young of Megalosaurus, the answer is, that the lower jaw of the Nuthetes differs from that of Megalosaurus in not having the inner alveolar wall developed in the same degree, and in not exhibiting any rudiments of alveolar divisions.* The inner wall is not produced in a greater degree than in the modern *Varani*. The largest teeth measure two lines in diameter at the base of the crown, which is more or less excavated on the inner side by the pressure of the matrix of a successional tooth.

The length of the largest fragment of the mandible was one inch and a half; the depth of the outer wall was six lines, that of the inner wall was from three to four lines. The exterior surface of the bone is smooth and polished, but shows under the pocket-lens very fine longitudinal linear markings; it is perforated by a series of nervo-vascular foramina along the alveolar wall, and is traversed near the lower margin by a line answering to the suture dividing the dentary from the angular piece in the jaw of *Varanus*.

The fossils give evidence of a carnivorous or insectivorous lizard of the size of *Varanus crocodilinus*, or great land-monitor of India. The specific name relates to the adaptations of the teeth for piercing, cutting, and lacerating the prey.

Of the vertebral characters I have not, as yet, received satisfactory evidence. *Nuthetes destructor* is referred solely on mandibular and dental characters to the "pleurodont section" of the order LACERTILIA. But, in the same division of the Purbeck strata, viz., from the "Feather Quarry," containing *Cyclas* and *Planorbis*, have been found long bones of a small Saurian and dermal scutes, agreeing, in regard to proportional size, with the jaw and teeth of *Nuthetes*. The bones present the characters of tibia and fibula, and are longer in proportion to their breadth than in any known recent form of Crocodilian; they are associated in the same slab with the scutes, which are subquadrate in form, about eight lines in one diameter and six lines in the opposite; smooth on the inside, impressed by minute, circular pits on the outside, and presenting more the character of the bony, dermal scutes of *Crocodilia* than of those of any known species of *Lacertilia* so defended. Additional evidence is needed to determine the relations of these small, pitted, dermal scutes to the bones and teeth of *Nuthetes*.

* 'Monograph on Megalosaurus,' vol. for 1856, p. 21.

Genus—Saurillus,* *Owen.*

Saurillus obtusus, *Owen.*

The fossils upon which the above genus and species were founded† were transmitted for my determination, in 1854, by Mr. W. R. Brodie, of Swanage, and were discovered by that persevering explorer of the Purbeck beds, in the "Dirt-bed," No. 93, of Mr. Austen's 'Stratigraphical List' above cited.

The most instructive specimen consisted of the right dentary element of the lower jaw, containing thirteen teeth. These are moderately long, conical, and obtuse; but are neither so long nor so recurved as in *Nuthetes*, nor are the crowns compressed, as in that genus. On the outer side of the dentary bone, not far below the alveolar border, are six nervo-vascular foramina in a longitudinal row, relatively as numerous and large as in Iguanodon, and indicating, as in that and other Saurian reptiles, the scaly covering of the jaws and the equally reptilian simple and subdivided condition of the salivary apparatus in *Saurillus*. The teeth are implanted according to the pleurodont type.

Supposing the fossil to have come from a mature individual, the size of the animal must have been nearly that of the common European lizard, *Lacerta agilis*. It was most probably insectivorous. The specific name, "*obtusus*," refers to the obtuse termination of the muzzle, as indicated by the form of the fore part of the jaw, and also to the blunt apices of the conical teeth.

Genus—Macellodon,‡ *Owen.*

Macellodon Brodiei, *Owen.* Tab. VIII, fig. 10.

In the slab of the fresh-water Purbeck stone containing the portions of upper and lower jaw, with teeth, on which the above genus and species were founded,§ there were also specimens of small, subquadrate, pitted, dermal scutes, and of a vertebral neural arch, corresponding proportionally in size with the teeth.

One specimen consists of the right superior maxillary bone, containing eight nearly entire teeth, and showing the places of attachment of thirteen or fourteen

* Abbreviation of *σαυρος*, *saurus*, a lizard.

† 'Quarterly Journal of the Geological Society,' No. 40, pp. 423 and 482.

‡ Μακελλα, *a spade*, ὀδους, a tooth.

§ 'Quarterly Journal of the Geological Society,' 1854, p. 422.

such teeth, the mode of attachment being by partial anchylosis to the bottom of an alveolar groove and to the side of an outer alveolar wall.

The crown of the teeth is broad, compressed, with sharp, subcrenate margins at the apical half, curving in most to a low point at the summit, and having a semicircular contour when this is worn away, as at *c*, fig. 10. A few of the anterior teeth are narrower, and the crenate margins converge, almost straight, to a sharper point, as in *a*, fig. 10. The older teeth have the crown reduced by attrition to the shape of a spade (*b*, fig. 10), suggesting the name of the genus. The enamel is marked by very fine, longitudinal ridges, the terminations of which give the crenate character to the unworn margins of the crown; a larger longitudinal rising marks the middle of the flattened surface, and is more conspicuous on the outer than the inner side of the crown in the lower jaw; it commences at a short distance from the base of the enamelled crown, and terminates at the apex. From this middle, thickest part of the crown the tooth narrows to the lateral margins, its transverse section across the middle of the crown resembling that of the upper part of the crown of the tooth of *Echinodon* (fig. 6, *b*).

In a portion of the upper maxillary bone of *Macellodon Brodiei*, the low palatal alveolar plate terminates internally in a smooth border, which had formed the outer boundary of an extended palatal vacuity, as in most lizards; this structure, with the unequal development, the succession, and pleurodont mode of implantation of the teeth, indicates the Lacertian affinities of *Macellodon*.

In a small slab from the lower part of the Purbeck stratum, called "dirt-bed, containing shells," Mr. Brodie discovered the dentary element of the lower jaw of *Macellodon*, containing thirteen teeth, and alveolar depressions for twenty; with this were associated the neural arch of a vertebra, portions of ribs, and some dermal, bony scutes. The teeth in place were anchylosed to depressions in an outer alveolar wall; a few at the fore part of the jaw were less expanded relatively to their length than the rest, which presented the Macellodont type of crown. They are separated by slight intervals, and the teeth are much smaller in proportion to the jaw than in *Nuthetes*. The dentary bone, figured of the natural size at Tab. VIII, fig. 10, presented the posterior notch for articulation with the angular and surangular elements; its outer surface is convex, and perforated at its anterior half by a linear series of nervo-vascular canals.

The neural arch associated with the above portion of lower jaw bears a greater proportional size thereto than in most lizards; it exhibits long diapophyses, as in the lumbar and anterior caudal Saurian vertebræ, supports a moderately long spine, and shows a small, circular, neural canal; the zygapophyses have been broken away from the exposed surface; and the centrum has been, apparently, detached from a sutural connexion with the arch, which would be rather a Crocodilian than a Lacertian character.

vegetable remains, high up the cliff, at Durdleston Bay, Isle of Purbeck. They consist of portions of the upper and lower jaws of a Saurian, allied, by the shape of the teeth, to *Macellodon*, but of much larger size, and with the thecodont implantation of the teeth. The crown belongs, in general shape, to that lamelliform, leaf- or scale-shaped type, of which the teeth of *Palæosaurus*, *Cardiodon*, *Hylæosaurus*, *Macellodon*, and even those of *Iguanodon*, are modifications. The teeth of the present genus are distinguished by the marginal serrations of the apical half of the crown, which increase in size from the apex to the base of that angular part of the tooth, the two basal points resembling spines, and terminating respectively, or forming the confluence of, the two thickened ridges (*r*, fig. 2, *c*) bounding the fore and hind borders of the basal half of the crown.

The crown is supported on a subcylindrical fang, and suddenly expands, both transversely (Tab. VIII, fig. 2, *c*) and antero-posteriorly (ib., *b*). In the former direction it as quickly begins to contract, and the outer and inner sides converge in almost a straight line to the apex; in the latter direction the crown continues expanding for about half, or rather more, of its longitudinal extent, with a slightly convex contour; it then rapidly contracts to the apex, the converging borders meeting at a right or somewhat acute angle, and being serrated as above described. The thickest mid-part of the crown forms a longitudinal rising, usually more marked on one side of the tooth; at the apical half the crown gradually becomes thinner towards the fore and hind margins; but at the basal half these margins are thickened, and cause the surface between them and the mid-rising to be undulated transversely. At the apical part of the tooth both the outer and inner sides are gently convex, the transverse section giving the thin-pointed ellipse, as in fig. 6, *b*.

The outer and inner enamelled sides of the crown each describe a curve at their base (fig. 3, *b*, *r*), convex towards the fang; these bases are somewhat thickened and rounded, so as to project from the fang; they converge at the fore and hind parts of the tooth, and unite at an acute angle (fig. 2, *c*, *r*), to form the long, basal points (fig. 3, *b*, *s*) of the serrated half of the crown. The foregoing characters apply to the majority of the teeth of *Echinodon*.

A portion of the left superior maxillary bone, imbedded in the matrix, with its outer surface exposed, is represented in Tab. VIII, fig. 1, and in outline, of the natural size at *a*. The anterior, probably premaxillary, part has been detached and broken. Three teeth, more or less fractured, project from sockets in the alveolar border of this part; their crowns are less expanded than in the typical maxillary and mandibular teeth. Part of the boundary of an external nostril is indicated at *n*. the larger maxillary fragment of the first two teeth present a similar form, and the entire crown of the second shows it to be longer, as well as more slender, than the posterior teeth; it resembles a canine tooth in both shape and position, the crown

their fangs in the sockets are shown in fig. 7; the anterior teeth are narrower than the rest, as in the upper jaw. The crushed or broken state of the specimen at the opposite end prevents a determination of the total number of sockets in this ramus. On the inner side of the specimen (fig. 8), a considerable extent of the symphysis (*s*, *s*) is shown.

The posterior part of a broken and distorted dentary element of the left ramus of the mandible is represented in fig. 9, showing the last eight teeth, and the impressions of the crowns of as many in advance. A portion of the crown, displaced, of the fourth from the last is preserved, and likewise portions also of those in advance, which have been broken in splitting the slab, so that they appear smaller than they actually were. The last three teeth are entire, and show a gradual decrease of size, as in the portion of upper jaw (fig. 4). A magnified view of the inner surface of the last lower tooth is given at *a*, fig. 9.

From the characters of jaws and teeth above described, the extinct animal presenting them might be referred to the modern Lacertian group: but the structure of the vertebræ and limb-bones must be ascertained before the ordinal affinities of *Echinodon* can be satisfactorily determined.

The modifications of the mode of implantation of the teeth in the known limits of the Dinosaurian order affect the value of the thecodont character as a mark of affinity. The dentition of *Echinodon*, in respect to the shape of the crowns of the teeth, appertains to the category embracing *Macellodon*, *Cardiodon*,* *Hylæosaurus*, and *Iguanodon*. From *Macellodon* the present genus differs in the swollen borders of the basal half and the stronger serration of the apical half of the dental crown. The similarly expanded crown of the tooth of *Cardiodon* has thicker and apparently not serrate margins, it is not divided into a basal and apical portion, and the apex is more obtuse. In *Hylæosaurus* the crown of the tooth is thicker and less expanded than in *Echinodon*; the borders of the apical half are usually abraded by masticatory acts, show no marks of serration, and meet at an angle of 80°; but the crowns of the teeth were in contact, as in *Echinodon*. The more complex structure of the teeth of *Iguanodon* appears, nevertheless, to be due to additions superposed upon a type of tooth which is essentially like that of *Echinodon*. The expanded crown is divided into a basal and apical portion; the marginal serrations of the latter are coextended with the increased thickness of the part into small lamellæ, themselves more minutely dentate. The middle longitudinal rising of the enamel, which in *Echinodon* has appeared to me to be stronger on the outer side of the upper teeth and on the inner side of the lower teeth, is exclusively developed, as the "primary ridge" on the corresponding aspects of the teeth of the upper and lower jaws in *Iguanodon*. In the small teeth, or those of the

* From the Oolitic Formation, called "Forest-Marble," near Bradford, Wilts. See my 'Odontography,' p. 291, pl. 75*a*, fig. 7.

TAB. VIII.

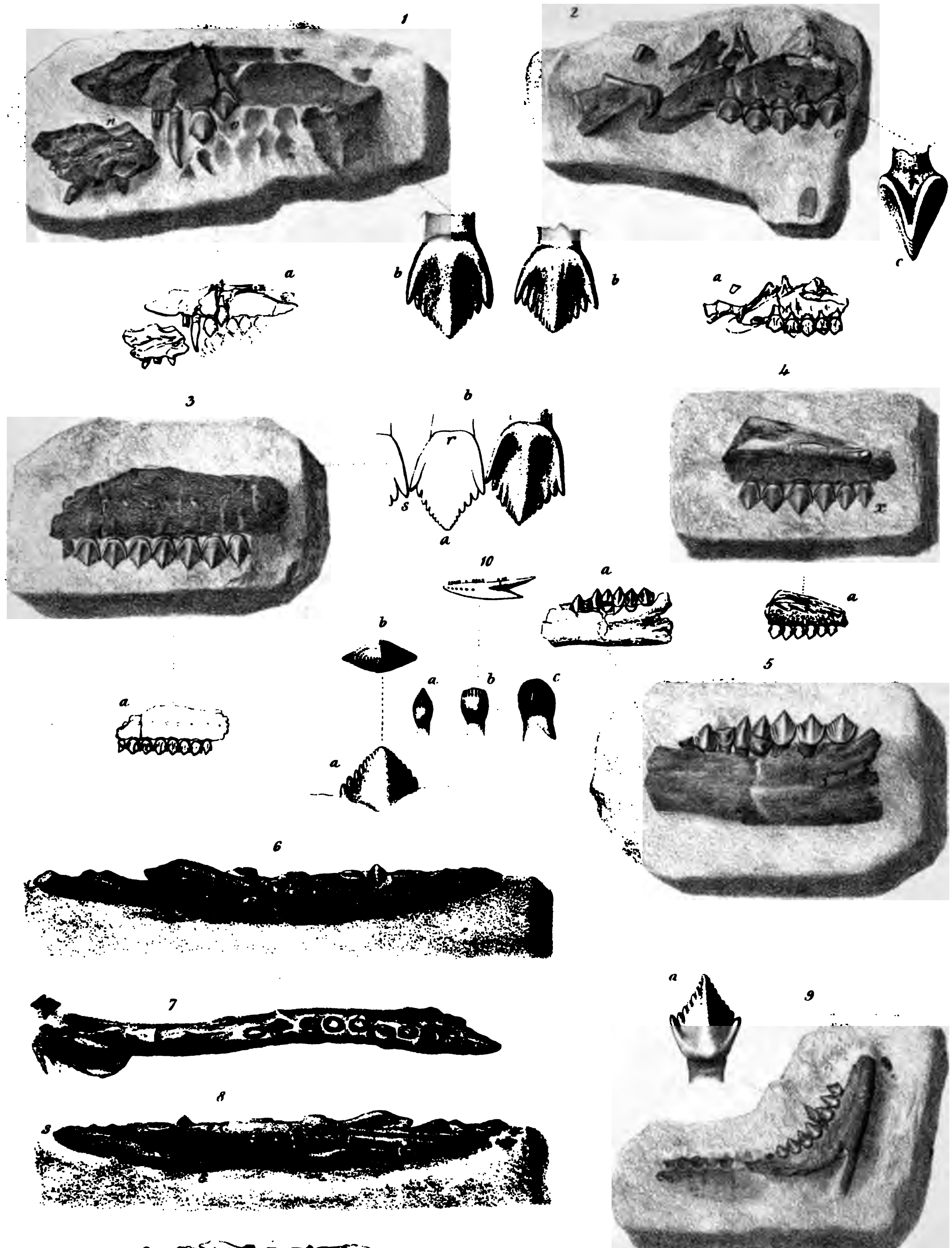
Echinodon Becclesii.

Fig.

1. Portion of the left upper jaw, outer side; *a*, nat. size, *b*, tooth magnified.
2. Ditto, inner side; *a*, nat. size, *b*, tooth magnified.
3. Portion of the upper jaw, outer size; *a*, nat. size, *b*, tooth magnified.
4. Portion of upper jaw, inner side; *a*, nat. size.
5. Portion of lower jaw, inner side; *a*, nat. size.
6. Anterior portion of right ramus of lower jaw, outer side.
7. Ditto, upper surface.
8. Ditto, inner side; *a*, nat. size, *b*, tooth magnified.
9. Portion of the lower jaw, twice nat. size; *a*, tooth magnified.

The foregoing figures are from specimens in the Collection of Samuel H. Beccles, Esq., F.R.S., and are from the Fresh-water beds of Purbeck, Dorsetshire.

10. Dentary element of left ramus of lower jaw of *Macellodon Brodiei*, nat. size; *a*, *b*, *c*, teeth magnified. In the Collection of W. R. Brodie, Esq., of Swanage, from the Fresh-water beds of Purbeck.



Dinkel lith.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. I.

PAGES 1—7: PLATES I—III.

DINOSAURIA (IGUANODON).

[WEALDEN.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

Issued in the Volume for the Year 1856.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1858.

SUPPLEMENT (No. I)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

ORDER—DINOSAURIA, *Owen.*

Genus—IGUANODON, *Mantell.*

IN the 'Monograph on the Iguanodon,' in a former volume of the publications of the Palæontographical Society,* the characteristic form of certain toe-phalanges was described; such phalanges, at least, were inferred to belong to the Iguanodon, with a high degree of probability, on evidence of association with other undoubted parts of the skeleton of that reptile, and more especially in the instance of the Maidstone skeleton;† but at that period the exact structure and number of toes of either fore or hind foot were unknown.

On the basis, however, of the determination of detached phalangeal bones in that Monograph, the present restoration of an entire—probably hind—foot, the carpus or tarsus excepted, of the Iguanodon, has been carried out; the ungual phalanges in the series of bones of this foot (T. I, II, III) closely corresponding in shape with the depressed and obtuse phalanges referred to that extinct animal in the above-cited volume, 1855, pp. 42—44. This most interesting and instructive framework of the foot of the great Dinosaurian herbivorous reptile was, moreover, found in a formation and at a locality where unequivocal vertebræ and other parts of the Iguanodon are common;

* 'Fossil Reptilia of the Wealden Formations,' Part ii, p. 40, t. xvi and xvii, (vol. for 1854.)

† 'Fossil Reptilia of the Cretaceous Formations,' Part i, p. 105, t. xxxiii, (vol. for 1851.)

so that it is with much confidence that the present contribution towards a complete reconstruction of the Iguanodon is now submitted to palæontologists.

The discovery and acquisition of the unique specimen, figured in T. I, II, and III, are due to S. H. Beckles, Esq., F.G.S., the author of the papers on the 'Ornithoïdichnites of the Wealden,'* and who first definitely called the attention of geologists to the singular "trifid," or tridactyle impressions in the Wealden of Sussex, of which he was the chief discoverer, and has been the most persevering investigator.

It seems a peculiarly appropriate reward for these researches, that the acquisition of the fossils demonstrating the tridactyle structure of one of the feet of the Iguanodon should have been reserved for Mr. Beckles. These fossils, moreover, were not fortuitously acquired, but were the fruit of special researches, assiduously carried on by Mr. Beckles on the south-west coast of the Isle of Wight, with a view to materials for completing our knowledge of the great Wealden reptiles.

Between Brook and Brixton, in the submerged Wealden bed, near low-water mark, indications of the entire skeleton of a young, perhaps half-grown, Iguanodon were detected. The bones of the foot which were most within reach had been very little disturbed. The metatarsus (T. II, fig. 2) was extracted in one piece; the phalanges of an outer toe (T. I, 1 IV—5 IV) were extracted in a second piece: they had been somewhat distorted at the time of imbedding, for the matrix had hardened around, and preserved them in that state. The phalanges of the toe of the opposite side of the foot (ib., 1 II—3 II) were extracted similarly cemented together by the matrix, but in their natural juxtaposition. Three of the phalanges of the middle toe (ib., 1 III—3 III) were also joined together by the matrix; the fourth, or ungual phalanx of this toe, was extracted separately; but Mr. Beckles's attention having been, unluckily, diverted to another subject at this time, the fossil got into the hands of an idle looker-on, who cast it into the sea. All the other bones of the foot Mr. Beckles caused to be carefully packed, and transmitted to me for description.

I employed a skilful lapidary to clear away the adherent matrix, and to separate the cemented phalanges of the distorted toe, for the examination of their articular surfaces, and the result of my comparisons were communicated briefly to the Geological Society of London, on the occasion of exhibiting the specimen at the meeting held June 17th, 1857.

As has already been stated, the bones, whether carpal or tarsal, which unite the foot proper to the limb, are wanting. The metapodium,† fortunately, yields the required proof of the precise number of toes.

* 'Quarterly Journal of the Geological Society,' January, 1851, and November, 1852.

† I use this word to signify the same segment in both fore- and hind-limbs: "metacarpus" is the specific term for the segment in the fore limb; "metatarsus" for that in the hind limb. But, in the gradual reconstruction of the skeleton of a strange reptile, it is requisite to have a term expressive of the more general kind of knowledge at first acquired. Metapodial is equivalent to metacarpal or metatarsal.

dilian and Lacertian characters, with superinduced Dinosaurian peculiarities, analogous to the plan of structure which I have had occasion to point out in other parts of its fossilized remains. So far as the Dinosaurian peculiarity of a reduced number of functional toes prevails, that order departs further from the general Reptilian type than do the existing Crocodiles and Lizards.

Having premised these general remarks on the fossils in question, I proceed next to point out the chief characters of the constituent bones of the foot.

The rudimental metapodial of the first or innermost toe (T. I, II, III, i) articulates by its proximal end with a notch, 9 lines in diameter, at the middle of the inner (tibial) surface of the second metapodial (ii). It seems not to have been anchylosed at this part, from the circumstance that the slender bone has been broken, soon after death or interment, and the upper portion has been displaced obliquely from the lower half, which maintains, perhaps through anchylosis, its natural position; the displaced portion is cemented in that position by the hardened matrix to the contiguous large metapodial.* The rudimental metapodial, 9 lines by 6 lines in the two diameters of its proximal end, gradually becomes more slender as it descends; its lower half is trihedral, and stands rather sharply out from the large metapodial (ii); its extremity is broken off; the large and small diameters of the lower fractured end are 5 lines and 3 lines. It is not probable that its presence was conspicuous beneath the integument which covered it, but it may have supported a rudimental toe and claw.

The second metapodial (ib., ii) is 8 inches in length, 4½ inches in the longest diameter of the proximal end, 3 inches in that of the distal end. The bone expands at both ends, more suddenly at the distal one; it is convex on its free or tibial side, flattened on the side next the third metapodial, with the anterior border produced near the middle of the shaft into a process with a convex outline, and with a ridge projecting from the inner and back part of the proximal end. This ridge has been fractured. The outer or fibular angle of the back part of the proximal end is produced towards the next large metapodial, but has likewise been fractured. The articular surface at this end is flat, rather rough, showing vascular pits and other evidence of having been covered, in the recent state, by a layer of fibro-cartilage: by which it was articulated to the innermost tarsal or carpal bone. The distal articular surface is convex from before backwards, slightly convex transversely at its anterior half, with a middle concavity and lateral convexities, transversely, at the posterior half, which is somewhat broader than the fore part of the joint, and with the outer (fibular) angle produced.

The inner (tibial) side of the distal end of this metapodial has a broad and shallow depression for the attachment of a lateral ligament; the articular surface is two inches

* In the figure it is represented as restored to its natural position.

expanding as it descends; concave, but in a less degree, transversely; with the inner (tibial) side of greater extent. On both sides the articular border is slightly raised, forming the lower boundary of the wide concavity for the attachment of the lateral ligaments.

The second phalanx (II 2) is broader than it is long, its extreme breadth being 2 inches 4 lines. The proximal articular surface, with its concavity and convexity the reverse of those of the surface on which it plays, is triangular, with the angles largely rounded off. The under surface of this phalanx is somewhat flattened; the upper surface is contracted; the distal trochlea, very convex vertically, is flat transversely, at its upper half, slightly concave below; the modification resembling that of the phalanx supporting the unequal one in the other toes.

The third phalanx (II 3), which supported the claw, presents an oblique basal articular surface, flattened transversely and produced backwards above; slightly convex transversely below. The unequal part is sub-depressed, obtuse, obliquely bent downwards and outwards, but in a slight degree; the base of the bone is notched at each side, where the vascular canals relating to the growth of the claw commence; they impress the upper and lateral parts of the bone, which is $4\frac{1}{2}$ inches in length.

The proximal phalanx of the middle toe (T. I and III, III 1), answering to the third in the Iguana, shows its increase chiefly in breadth and thickness; its length is $4\frac{1}{2}$ inches. The proximal end, of a transversely oval form, is slightly and irregularly concave; its distal end is broader but less deep than that of the outer toe, and the shape of the trochlea is more symmetrical; the outer slightly exceeds the inner side in extent. The increase in the transverse over the longitudinal and vertical diameters is more marked in the second and third phalanges (III 2 and 3) of the middle toe; the latter phalanx shows the same flatness transversely, at the upper part of its distal trochlea, as in the corresponding phalanx of the outer toe. This structure indicates the next phalanx to have been an ungual one, resembling, as Mr. Beckles informed me, in its general character, the long terminal phalanx in the adjoining toes. It is indicated in outline in T. I, 4 III.

All the five phalanges of the outer toe (IV 1, 2, 3, 4, 5) are preserved; the entire length of the toe is $8\frac{1}{2}$ inches, being rather shorter than the inner, but apparently longer from the lower position of the metapodial bone (IV). In this proportion the Iguanodon differed from existing Lizards, and resembled the Crocodiles.

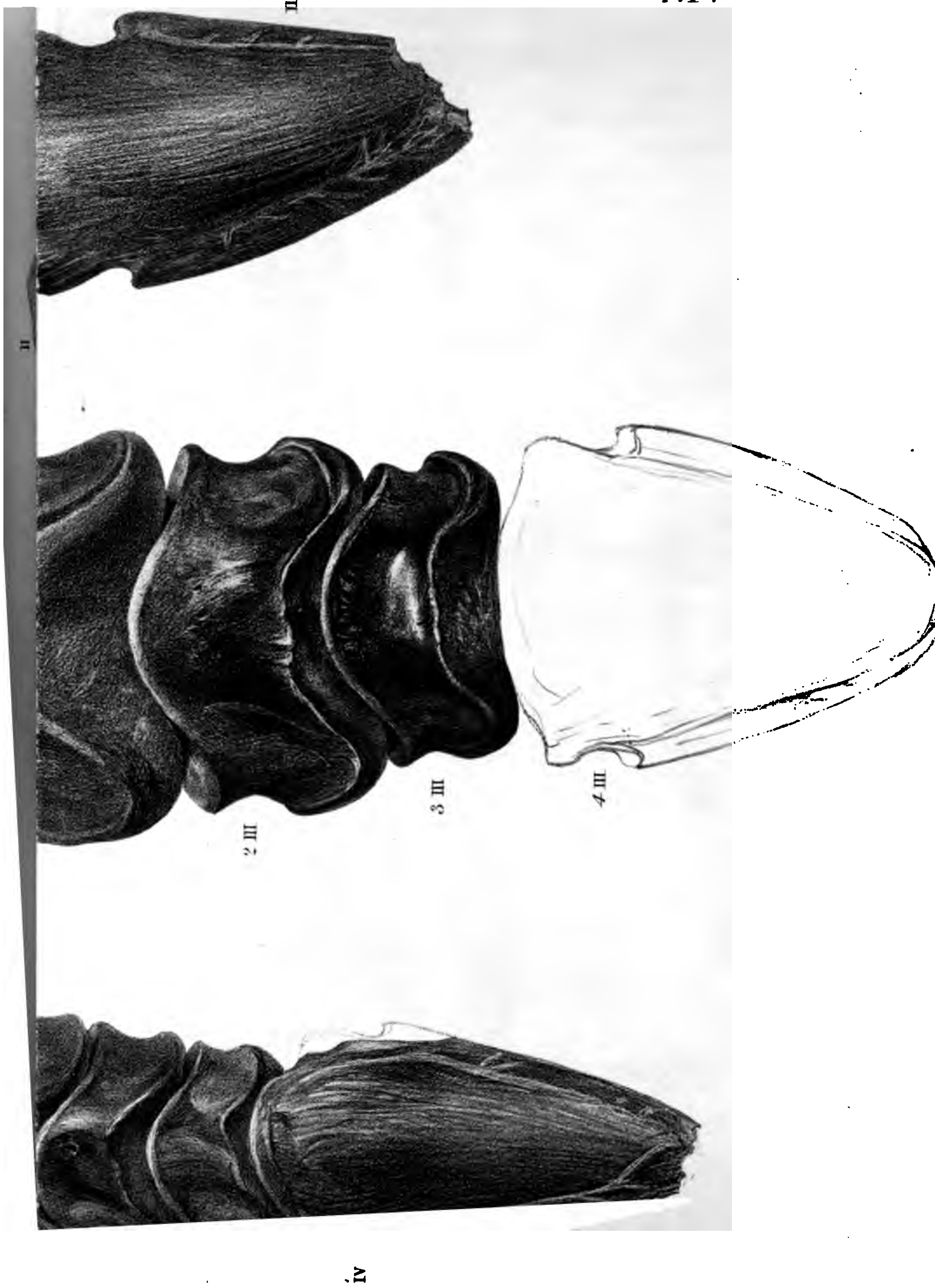
The proximal phalanx of the outer toe (IV 1), answering to the fourth in the Iguana's foot, is 3 inches in length, with a subtrihedral body, one side turned to the next toe, and one angle inwards and downwards. The proximal surface is flat; the distal one trochlear, but with the transverse concavity less deep than in the first phalanx of the inner toe. The three succeeding phalanges (IV 2, 3, and 4) are similar in character, but progressively decrease in size; they are very short in comparison to their breadth.

TAB. I.

Foot of a young Iguanodon, upper or front view; nat. size.

From the submerged Wealden Beds, South Coast, Isle of Wight. In the Museum of Samuel H. Beccles, Esq., F.G.S.

T. I.



TAB. II.

Metapodium of a foot of a young Iguanodon, nat. size.

Fig.

1. Proximal articular ends of the three principal bones, II, III, and IV, and of the anchylosed rudimental bone, I.
2. Under or back view of the same bones.
3. Distal articular ends of the three principal bones.

From the submerged Wealden Beds, South Coast, Isle of Wight. In the Museum of Samuel H. Beccles, Esq., F.G.S.

TAB. III.

Parts of the foot of a young Iguanodon, nat. size.

Fig.

1. Inner or tibial side view of the second toe, II, with rudiment of the first, I.
2. Inner or tibial side view of the first, second, and third phalanges of the middle toe.
3. Outer or fibular side view of the fourth or outer toe.

From the submerged Wealden Beds, South Coast, Isle of Wight. In the Museum of Samuel H. Beccles, Esq., F.G.S.

T. III.

From Nature on Stone by J. Erxleben.

Day & Son, Lith^rs to The Queen.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. II.

PAGES 20—44; PLATES V—XII.

CROCODILIA (STREPTOSPONDYLUS, &c.)

[WEALDEN.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1859.

SUPPLEMENT (No. II)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

ORDER—*CROCODILIA.*

Genus—STREPTOSPONDYLUS, *Von Meyer.*

THIS name, from the Greek στρέφω, I turn, σπονδύλος, vertebra, was applied by M. Hermann v. Meyer to the Crocodilian reptile distinguished by Cuvier as the "second espéce de Crocodile de Honfleur,*" and characterised by the same great anatomist as "having the cervical and anterior dorsal vertebræ, with the articular ends of the centrum, convex in front and concave behind."† By this character was distinguished the "second Gavial of Honfleur" from a "first Gavial of Honfleur," in which the articular ends of the centrum were both slightly concave.

With regard to these kinds of fossil vertebræ Cuvier writes: "je nommerai l'un *système convexe* en evant, et l'autre *système concave.*"‡ To the former he referred a gavial-like skull with a shorter and more obtuse upper jaw, and a less depressed symphysis of the lower jaw;§ to the latter a more gavial-like skull, with longer and more slender jaws.||

* 'Ossemens Fossiles,' ed. 8vo, 1836. Explication des Planches, p. 78, pl. ccxxxviii, figs. 5, 6 et 7.

† Ib., t. ix, p. 309.

‡ Ib., p. 308.

§ Subsequently named *Steneosaurus rostro-minor*, by Geoffroy St. Hilaire.

|| *Steneosaurus rostro-major*, ib.

Certain vertebræ of the "anteriorly convex" system were further distinguished by the origin of the transverse process from salient ridges converging so as to form a pyramidal base of such process, and by a deep depression behind the costal facet. These characters are peculiar to the anterior dorsal vertebræ. In the posterior dorsal and lumbar vertebræ, recognised by Cuvier as belonging to the same "seconde Gavial de Honfleur" by the character of the pyramidal base of the transverse process, the anterior convexity had subsided: even in a dorsal vertebra, in which the articular surface for the head of the rib is still distinct, only a little higher placed, the terminal articular surfaces of the centrum are nearly equal and flat, "a peu près égales et planes."*

Upon the discovery of "opisthocœlian" vertebræ, or those of the "système convexe en avant" in the Wealden formations,† I threw out the suggestion ‡ that, as in the second Honfleur Gavial, they might be the anterior vertebræ of a large Wealden Saurian, having vertebræ with flattened terminal surfaces in a more posterior part of the spine. Observing, also, that such vertebræ, in the *Cetiosaurus brevis*, were slightly concave behind, though flat in front, it seemed to me that this genus might have the best claim to them. But, after pointing out the difference in the antero-posterior diameter of the large convexo-concave and plano-concave vertebræ, I remarked that "additional evidence of a very decisive character must be obtained before the great Cetiosaur can be admitted to have resembled the Pterodactyle in such disproportionate length of the cervical vertebræ."§

No discovery of the long convexo-concave or opisthocœlian vertebræ, so associated with short plano-concave or bi-concave vertebræ, as to have belonged to the same animal, has yet been made, though nearly twenty years of quest and collection of Wealden fossils have passed since the importance of that additional evidence was pointed out. I, therefore, still feel myself without the requisite grounds for a decisive settlement of the question of the genus of the long and large opisthocœlian vertebræ of the Wealden, and continue to refer them, provisionally, as in my 'Report,' to a species of *Streptospondylus*.‖

* 'Ossemens Fossiles,' tom. cit., p. 311.

† Previous to my Report on British Fossil Reptiles, 'Trans. British Association,' 1841, these vertebræ had been deemed "procœlian;" and, in the question of which of the various-shaped Wealden vertebræ might belong to the *Iguanodon*, Dr. Mantell thought that "the concavo-convex vertebræ which correspond so entirely to those of the *Iguana* and *Monitor*, would seem to offer a more probable approximation" ('Geology of the South-east of England'); only their extreme rarity opposed the hypothesis.

‡ 'Report on Brit. Fossil Reptilia,' ib., p. 96.

§ Ib.

‖ Report on British Fossil Reptiles, 'Trans. Brit. Association,' 1841, p. 91. The futility of subsequent speculations on this subject, in the 'Philosophical Transactions' of 1849, p. 286, has been shown by the discovery of the true cervical vertebræ of the *Iguanodon*, described in my 'Monograph' of 1855.

STREPTOSPONDYLUS MAJOR, *Owen*. Tab. V, VI.

The vertebræ so named, in the British Museum, and in that of the late Mr. Saull, F.G.S., now transferred to the Literary Institution, Aldersgate Street, London, have belonged to the region of the neck, or fore-part of the back, and were obtained from the Wealden formation of three localities, viz., Tilgate Forest, in Sussex; Culver Cliff, Isle of Wight; and Brook Point, Isle of Wight. They differ from the convexo-concave vertebræ of *Streptospondylus Cuvieri*, from the Lower Oolite and Lias, in their much larger size, and in the absence of the deep pit behind the costal facet. The converging, buttress-like ridges on the sides of the neural arch appear to be developed only in the anteriorly convex vertebræ of the dorsal region (Tab. VI, fig. 5, *a*, *b*).

Cervical vertebræ. Tab. V, figs. 1 and 2. Tab. VI, figs. 1, 2, and 3.

The cervical vertebra (Tab. V, figs. 1 and 2) measures six inches in length. The anterior end of this vertebra is determined by the aspect and position of the zygapophysis (ib. *z*), which, as its articular surface looks obliquely upward and inward, and is on a lower level than the oppositely turned process (*z'*), must be the anterior one. The corresponding extremity of the centrum (ib. *b*) is convex; the opposite extremity, which is somewhat overhung by the higher placed posterior zygapophyses (*z'*), is concave, as shown in fig. 2, *c*. The whole vertebra is a little crushed obliquely. The fore part of the centrum is further indicated by the position of the parapophysis (ib. figs. 1 and 2, *p*) or transverse process for the articulation of the head of the rib; at least, according to the analogy of the *Crocodilia*, in which it comes off nearer the anterior than the posterior end of the centrum.* Beneath the parapophysis (*p*) the sides of the centrum are concave, and converge downward to a broad ridge (Tab. VI, fig. 2, *h*), which terminates (at *h*) the anterior part of the lower surface of the vertebra, and corresponds with the hypapophysis given off from that part in the cervical vertebræ of the Crocodile.† A second concavity, at the upper part of the side of the body, separates the parapophysis from the base of the neural arch; from which a diapophysis (upper transverse process) is developed for the attachment of the tubercle of the rib. The diapophysis (Tab. V, fig. 1, *d*) comes off from the under and outer side of the anterior zygapophysis (ib. *z*). The articular facet of the latter process presents a full, oval figure; it is slightly raised at its outer part from the horizontal position. There

* See 'Monograph on the Reptilia of the London Clay,' 1850, t. ix, fig. 3, *p*: (*Crocodilus Hastingsiæ*).

† Ib., figs. 2 and 4.

is but little trace of spinous process from the somewhat fractured summit of the neural arch; this appears to be truncate in front, but has suffered some injury there, permitting the fore part of the neural canal and the whole anterior articular ball to be seen in a direct vertical view (as in figs. 1 and 3, Tab. VI). The back part of the neural arch appears to be deeply cleft through the backward production and divergence of the posterior zygapophyses.

In the collection of fossils of the late Mr. Saull, F.G.S., now in the Museum of the Literary Institution, Aldersgate Street, London, there is a cervical vertebra of *Streptospondylus major*, associated, as in the Mantellian Collection, with vertebræ of the *Iguanodon* and *Cetiosaurus*, all of which have been washed out of the submarine Wealden beds at the south side of the Isle of Wight, and thrown on shore near Culver Cliffs and Brook Point.

The lower half of the sides of the centrum of this vertebra of the *Streptospondylus* are, like the preceding vertebra from Tilgate, concave and obliquely compressed, so as to converge to the anterior part of the under surface (Tab. VI, fig. 2), which thus presents a triangular form, with the apex forming the obtuse anterior ridge (*h*), and the base turned backward and becoming somewhat flattened. Each lateral concavity is bounded above by a short but broad parapophysis (ib. *p*), developed from the anterior half of that part of the centrum, and terminated by an oblong flattened surface for the articulation of the head of the cervical rib; which surface is about twice as long in the antero-posterior as the vertical direction. Above this process the centrum is again concave, but there is no pit or defined cavity behind its process. The base of the neurapophysis is anchylosed to nearly the whole antero-posterior extent of the centrum, the course of the original straight suture being, however, discernible. A diapophysis is developed from the side of the base of the neurapophysis, affording a broader surface for the tubercle of the cervical rib than does the parapophysis for the head. Above the diapophysis the neurapophyses converge obliquely to the base of the spinous process. The line of the base of the spine inclines forward, and the thickness of the spine diminishes in the same direction. The posterior zygapophyses in the cervical vertebra from Culver Cliff, are similar in all respects to those in the Tilgate specimen, and equally determine the fore and hind extremities of the vertebra.

The difference in the height of the neural arch, and in the configuration of its external surface, which both the cervical vertebræ of the great Wealden *Streptospondylus* present, when compared with the dorsal vertebræ of the smaller species from the older oolitic formations,* is very great; and the more remarkable, as in the existing Crocodiles the height of the neurapophyses is greater in the cervical than in the dorsal region. Since, however, the diapophyses in the Crocodiles come off from a higher part of the neural arch in the dorsal than in the cervical vertebræ, the spine of the great Wealden *Streptospondylus* may possibly present modifications in the dorsal

* *Streptospondylus Cuvieri*, 'Ossemens Fossiles,' tom. cit., p. 308, pl. ccxxxvi.

region corresponding with those remarkable ones which Cuvier has described in the vertebræ from Honfleur.

A more posterior cervical vertebra of ***Streptospondylus major*** (No. 28,508, British Museum), from the submerged Wealden beds at Brook Point, Isle of Wight, shows that these vertebræ increase in height as they recede from the head.

In the present specimen the parapophysis is still developed from the side of the centrum and from its anterior half; but it expands more rapidly as it approaches the terminal ball, with which its own articular surface seems to be continuous. The side of the centrum behind the parapophysis is convex vertically at its upper half, slightly concave vertically as it descends to the thick inferior convex ridge, which is broadest behind, as in the more advanced and longer vertebræ.

The diapophysis is now supported by a thick, rounded prominence, beginning near the lower and hinder part of the neural arch, and, expanding as it rises, it advances to the base of the diapophysis; this is the beginning or rudiment of the hinder converging ridge in the type vertebra of *Streptospondylus*, as described and figured by Cuvier.*

The neural canal has the same shape and relative size as in the more advanced vertebra (Tab. V, figs. 1, 2, and 3). The pedicles or bases of the neural arch present the same superior thickness, as compared with the *Iguanodon*, showing a convex, rounded border behind as well as in front. There is a median depression at the back part of the base of the neural spine.

The following are admeasurements of the bodies of the above-described three cervical and anterior dorsal vertebræ of the Wealden *Streptospondylus*:

	Tilgate.		*Culver Cliff.*		*Brook Point.*		*Dorsal.*	
	Inch.	Lines.	Inch.	Lines.	Inch.	Lines.	Inch.	Lines.
Transverse diameter of posterior concave articular surface	5	0	6	0	6	0	5	6
Vertical diameter of posterior concave articular surface	3	6	4	6	5	0	6	0
Antero-posterior diameter of entire vertebra .	6	0	5†	0	6	0	5	9
Transverse diameter of the body across the parapophyses	6	0	6	6	6	6	....	
Height from lower surface of centrum to the hind part of base of spine	....		7	9	10	0	10	6
Antero-posterior extent of parapophysis . .	2	2	2	4	2	9	....	
Interspace between upper and lower transverse processes	....		2	0	2	9	....	

In the museum of the Geological Society of London there is a collection of rolled

* Loc. cit.

† It is evident that an inch at least, perhaps more, has been chiselled away from the ball which terminated the anterior end of the body of this specimen in Mr. Saull's collection.

vertebræ from the coast at Brook Point, Isle of Wight, which, among the bones of *Iguanodon* and other gigantic Wealden genera, contains the centrum or body of a dorsal vertebra of the great *Streptospondylus*. This specimen, though much rolled and worn, is interesting, inasmuch as it exhibits the characteristic contraction of the middle and expansion of the ends of the centrum, together with unequivocal evidences of the marked depression on each side, near the upper part of the anterior or convex end of the centrum. What remains of the depression is about the size of the end of a man's thumb. The convexity of the anterior extremity resembles in degree, and likewise in irregularity, that in the fractured vertebra of the *Streptospondylus* from the lower Oolite, in Mr. Kingdon's collection.

The present centrum is less depressed than those of the cervical region, but agrees with them in length, as the following dimensions show:

	Inch.	Lines.
Antero-posterior diameter	5*	0
Vertical diameter of concave end	5	6
Transverse diameter of concave end	5	3
Transverse diameter of middle of centrum	3	0

In Tab. V, fig. 4, a reduced figure of two of the anterior (cervical?) vertebræ of the young *Iguanodon* from Cowleaze Chine, is reproduced to show the difference in the form of the angle between the ridges diverging from the neural spine to the posterior zygapophyses, and in the form of the ridges themselves, which are much sharper in *Iguanodon* than in *Streptospondylus major;* the degree of the terminal convexity and concavity of the centrum are both less marked in the *Iguanodon*.

Dorsal vertebra of Streptospondylus major. Tab. VII.

I am now able to carry out the comparison of the Iguanodont and large Wealden Streptospondylian vertebræ at the part of the dorsal region where the parapophysis has passed from the centrum to the neural arch, and this is decisive against the ascription of the latter vertebræ to the *Iguanodon*.

That the dorsal vertebra, with a convexo-concave centrum, belongs to the same species as the cervical vertebræ here described and referred to *Streptospondylus major*, is shown by the same vertical contour of the sides of the centrum, convex at the upper and concave at the lower half, and by the shape of the thick, obtusely rounded, inferior median ridge, which still shows the triangular form with the posterior base, and is slightly convex lengthwise (Tab. VII, fig. 3). In the corresponding vertebra of the *Iguanodon* the upper half of the side of the centrum is slightly concave vertically, and

* The margins of the extremities being worn and rounded prevent the actual length being given.

the lower half convex, the converging sides here terminating in a sharp ridge, which is concave lengthwise (ib., fig. 6).

In *Streptospondylus major* the centrum loses in length and gains in height; the neural arch at the same time augmenting in height as the vertebræ recede from the neck. In the dorsal vertebra here described, there appears another Streptospondylian character, pointed out by Cuvier in the Harfleur gavial-like species, the support, viz., of the transverse process by ridges, converging to its base. The anterior ridge (ib., fig. 2, *a*) ascends almost vertically in front of the surface (*p*, fig. 2) for the head of the rib, the posterior ridge (*e*), forming the outer and back part of the neural arch, ascends obliquely forward to meet the first ridge beneath the diapophysis (*d*).

In the *Iguanodon* the first ridge (*a*, fig. 4) is hardly represented; the second (*e*) is well developed, but is nearly vertical. The chief difference, however, which the vertebræ here compared of *Iguanodon* and *Streptospondylus* present, is seen in the structure of the neural arch behind the posterior ridge.

In *Streptospondylus major* the surface of the neural arch is continued from the posterior ridge inwards and a little backwards, almost flat, to the thick, rounded border of the posterior aperture of the neural canal, expanding with a slight concavity to the base of the posterior zygapophysis. In *Iguanodon* the corresponding part of the neural arch, viz., behind the posterior ridge (fig. 5, *e*), is excavated by a large and deep cavity.

The neural canal in *Iguanodon* (fig. 5, *n*) is relatively smaller than in *Streptospondylus*, especially narrower, its area presenting the form of a vertical ellipse, whilst in *Streptospondylus* it is a wide transverse ellipse (fig. 1, *n*). In *Iguanodon* a ridge formed, as it were, by the lateral compression of the back part of the neural arch between the two large hollows behind the buttresses of the diapophyses, rises vertically to the median approximate extremities of the posterior zygapophyses (fig. 5, *z'*). A broad, vertically convex surface, holds the place of the above ridge in *Streptospondylus*. The forepart of the neural spine is thicker in *Streptospondylus* than in *Iguanodon*, and there is a deeper and more circumscribed cavity on each side of that part of the spine on the roof of the neural arch. The side walls of that arch are much thicker in *Streptospondylus*, especially anteriorly, and the arch is shorter in proportion to the centrum than in *Iguanodon*. With all these differences between answerable dorsal vertebræ of *Iguanodon* and *Streptospondylus*, there remains the capital one of the front ball and hind cup in the latter, where the corresponding surfaces are flat or very slightly depressed in the *Iguanodon*.

The determination of the true nature of the convexo-concave vertebræ of the Wealden, and of the affinities of the reptile to which they belonged, besides extending our knowledge of the gigantic oviparous animals of that epoch, removes one of the chief difficulties attending the determination of the true vertebral characters of the *Iguanodon*. For, if gigantic vertebræ, agreeing in the important character of their articular surfaces with the existing *Iguanæ*, had actually been discovered, though of

rare occurrence, associated with teeth of corresponding dimensions, but similar in form to those of the Iguana, there would have been strong ground for suspicion that such vertebræ and teeth might have been parts of the same species.

We now know, however, that certain of the cup-and-ball vertebræ are of a kind more nearly resembling those of an extinct Crocodilian, with teeth very different from either those of *Iguanodon* or of the modern diminutive *Iguanæ*. The elimination of these, otherwise perplexing ball and socket-jointed vertebræ, forms, therefore, an essential step in the appropriation to the *Iguanodon* of its proper vertebral type.

Genus—Cetiosaurus, *Owen*. Tabs. VIII, IX, and X.

In the notices of the various forms or types of vertebræ from the Wealden strata, published by their persevering investigator, Dr. Mantell, prior to 1841, he states* that "his first step was, with the able assistance of the Rev. W. D. Conybeare, to separate those that belonged to the Crocodile, Plesiosaur and Megalosaur, or at least the vertebræ which most resembled those from Stonesfield."

Many enormous vertebræ remained, which are referred, in the Mantellian Catalogue of the collection subsequently purchased for the British Museum, to the *Iguanodon*. From these residuary specimens I separated, in my 'Report on British Fossil Reptiles,' of 1841, the vertebræ characteristic of the genera *Poikilopleuron*, Deslong., *Streptospondylus*, v. Meyer, and *Cetiosaurus*, which latter genus had previously been characterised by vertebral peculiarities observed in specimens obtained from older Oolitic strata.

Of the existence of vertebræ of this genus in the Wealden strata, I first became acquainted by the examination of the late Mr. Saull's collection of sea-rolled fossils washed out of the submerged Wealden beds, and deposited on the shores of the Isle of Wight, at Sandover Bay.

The vertebræ in question presented the well-marked generic characters of those of the dorsal region in the *Cetiosaurus longus* of the middle Oolite, as, *e. g.*, the breadth of the centrum, its subcircular contour, its median contraction and unequal concavity of the articular extremities; as, also, the short antero-posterior extent of the neurapophyses and their anchylosis to the anterior part of the upper surface of the centrum: but they differed from the vertebræ on which the characters of the present genus were first founded† by the shortness of their antero-posterior diameter as

* 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 76; 'Geology of the South-east of England,' 8vo, 1833, p. 278.

† See 'Proceedings of the Geological Society' for June, 1841.

compared with their breadth and depth, whence I proposed to designate the species by the name of *Cetiosaurus brevis.*[*]

The centrum of a dorsal vertebra of this species from Culver Cliff measures,

	Inch.	Lines.
in antero-posterior diameter	3	6
transverse diameter	6	4
vertical diameter	6	0

The hind articular end (Tab. IX, fig. 2, *b*) is moderately concave: the front end (ib., *a*) from the wearing away of the margins, appears slightly and unevenly convex. The contracted middle part of the vertebra is concave lengthwise, and pretty regularly convex in the direction transverse to the axis of the vertebra: the free surface is finely striated, and perforated here and there by vascular foramina: there is no lateral depression. The bases of the neurapophyses, instead of having their long diameter corresponding with the axis of the vertebra, as in *Iguanodon,* present it in the direction transverse to that axis, as in *Plesiosaurus:* they do not quite meet at the middle of the upper or neural surface of the centrum, but are there divided by a narrow longitudinal tract forming the lower part of the spinal canal.

The antero-posterior extent of the anchylosed base of the neural arch (ib., *n*) is 2 inches 6 lines: the transverse diameter of the arch is 5 inches.

The caudal vertebræ of the same species, also from Culver Cliff, present the same length and unequal concavity of the articular extremities; the anterior one, here determinable by the anterior position of the narrower hæmapophyses, being the deepest: the sides of the body are more compressed, and more convergent towards the under surface; so that, as the expanded margins of the articular ends are worn away, the centrum presents rather a triangular than a subcircular contour. The disproportion of its antero-posterior with its transverse and vertical diameters, distinguishes it from the caudal vertebræ of the *Iguanodon.* The neurapophysis rises from the anterior three fourths of the centrum, and sends forward a subprismatic anterior oblique process, but does not develope a posterior one: it then contracts, and inclines to the base of the spine, which is much shorter than in the *Iguanodon.* The spinous process inclines backward from the vertical axis of the centrum at an angle of 45°. A short transverse process is developed from the junction of the neurapophysis with the centrum. The hæmapophysial surfaces appear single on both the anterior and posterior parts of the lower surface; they are nearly flat, and slope towards each other.

* 'Report of British Fossil Reptilia,' 1841, 'Trans. Brit. Association,' p. 94.

The following are the dimensions of the best preserved of these vertebræ:

	Inch.	Lines.
Antero-posterior diameter of centrum	3	0
Transverse diameter	5	0
Vertical diameter	5	0
Height of vertebra to summit of spine*	12	9
Antero-posterior diameter of spine	2	10
Thickness at posterior part of base	1	0
Height of spine, 1st caudal	5	0
Height of spine, 2d caudal†	4	0

The characters and dimensions of these rolled vertebræ of *Cetiosaurus* from the submarine beds of the Wealden formation, although somewhat obscured by the circumstances under which they are brought to light, are sufficiently satisfactory to establish their generic character, and to give an useful approximative idea of their size and proportions. The corresponding bones from the Wealden of Tilgate Forest supply, by their more perfect state of preservation, the deficiencies of the Isle of Wight specimens, and further establish the co-existence of the *Cetiosaurus* with the *Iguanodon*, *Hylæosaurus*, *Streptospondylus*, *Megalosaurus*, and other extraordinary reptiles of that period. The vertebræ of the *Cetiosaurus brevis* in the Mantellian Collection are amongst the most gigantic specimens of Saurian remains that enrich it. They include almost entire specimens and bodies of two dorsal vertebræ (Tabs. VIII and IX) and four entire caudal vertebræ, which, if not consecutive, seem to have come not from distant parts of the basal portions of the tail of the same individual.

No. $\frac{133}{2133}$ "Gigantic vertebra of *Iguanodon*," MS. Catalogue of Mantellian Collection (Brit. Mus.), is a posterior dorsal vertebra of the *Cetiosaurus brevis*, and exhibits in a striking manner the peculiar characters of this species, viz., the great depth and breadth, especially the latter dimension (Tab. VIII), as compared with the length or antero-posterior diameter (Tab. IX) of the centrum or body of the vertebra.

The posterior articular surface (Tab. IX, fig. 2, *b*) is, in this region of the spine, more concave than the anterior surface, a structure which approximates to that peculiar one which characterises the *Streptospondylus*. The contour of the articular ends is subcircular, the transverse diameter being somewhat in excess. The centrum is contracted between the two articular ends, is slightly concave in the longitudinal direction at the upper part of the side of the centrum, but deeply concave below, and with a slight indication of a broad, obtuse, longitudinal ridge (Tab. IX, fig. 1, *r*), along the middle of the concave under surface. In the *Iguanodon* the sides of the vertebral body are nearly flat in the vertical direction; in the *Cetiosaurus* they are strongly convex. The surface at the middle of the vertebra is longitudinally striated

* This is rounded off, but seems not to have been broken.

† The 1st and 2d do not here refer to the place of these vertebræ in the tail; but if the vertebræ were contiguous in the entire animal, the tail must be much shorter than in the *Iguanodon*.

with very fine, subparallel, short impressions; these grow deeper and more irregular at the thick, rugged, and everted margins of the articular ends.

The neurapophyses are firmly anchylosed here, as in the caudal region, and the line of the primitive suture is hardly discernible: their base is shorter than the short centrum, and is attached nearer its anterior part; in the *Iguanodon* the neural arch is very nearly coextensive in antero-posterior diameter with the centrum supporting it; in a dorsal vertebra of an *Iguanodon* $4\frac{1}{2}$ inches in breadth, the antero-posterior extent of the base of the neural arch is 4 inches; in the present vertebra, which exceeds 7 inches in breadth, the antero-posterior extent of the neural arch is $2\frac{1}{2}$ inches, and only 2 inches a little above the base. The outer side of the neurapophysis is convex in the axis of the vertebra, and concave in the opposite direction as it ascends to the base of the diapophysis, showing only the posterior of those ridges and hollows that so singularly characterise the same part in the dorsal vertebræ of *Streptospondylus Cuvieri*. The antero-posterior diameter of the base of the diapophysis is 2 inches, its vertical diameter 1 inch. The diameter of the neural canal (*n*) is 1 inch 9 lines. The articular surfaces of the anterior zygapophyses (Tab. IX, fig. 1, *z*) are flat, and look upward and slightly inward and forward. In the *Iguanodon*, their under margins, in the dorsal vertebræ, converge at nearly a right angle; in the present vertebra they incline to each other at an angle of 40°. The spinous process begins to rise immediately behind the anterior zygapophyses by a narrow vertical plate, which seems as if it were nipped in between two shallow depressions; its base ascends obliquely, and grows thicker to the posterior part of the neural arch. The summit was not entire in any of these vertebræ.

The height of this dorsal vertebra to the posterior origin of the spinous process is $9\frac{1}{2}$ inches; from the base of the neurapophysis to the upper part of the transverse process, measures 3 inches.

No. $\frac{115}{2115}$ in the Mantellian Collection, British Museum ("Vertebra of *Iguanodon*, 8 inches in diameter," MS. Catalogue), may have actually presented that dimension when entire, for even now, not allowing for the margin of the posterior articular surface which has been broken away, it measures 7 inches across the surface. This remarkable specimen, which may probably have afforded the type of the "third or plano-concave" vertebral system, in the summary of the vertebral characters of the Wealden reptiles given by Dr. Mantell in his 'Geology of the South-east of England,'* and which accords best with the characters assigned by M. H. von Meyer to the vertebræ of the *Iguanodon*,† presents, in fact, in a striking degree, those of the vertebræ of the *Cetiosaurus*, and belongs to a more posterior part of the dorsal region, perhaps to the loins, of the same individual, certainly to one of the same species, as the vertebra (No. 2133) last described. A figure of a corresponding vertebra bisected vertically is given in Tab. IX, fig. 2.

* 8vo, 1833, p. 292, fig. 3.

† 'Palæologica,' p. 212.

The anterior articular extremity in one of these vertebræ makes an approach to a plane surface, being slightly concave transversely below, and very slightly convex above; vertically it is very slightly convex; the depth of the posterior concave surface at the centre is 9 lines. The general contour of the centrum has begun to change from the circular to the subquadrate, which latter figure is more decidedly expressed in the anterior caudal vertebræ of *Cetiosaurus brevis* (Tab. X).

The upper half of the sides of the centrum are more concave in the axis of the vertebra than in No. 2133. The free surface presents the same degree of smoothness, and is pierced here and there by moderate-sized vascular foramina. The neural canal makes a slight depression in the upper part of the centrum; in the *Iguanodon* it is encompassed by the bases of the neurapophyses. The transverse diameter of the neural canal is 1 inch, which small dimension satisfactorily distinguishes the present enormous vertebra from those of the mammiferous class, viz., the Cetacea, to which in other respects it has the greatest similitude. The antero-posterior diameter of the base of the neurapophysis is 2 inches.

The four anterior caudal vertebræ in the Mantellian Collection, which are here assigned to *Cetiosaurus brevis*, slightly increase in antero-posterior diameter, as is the case with *Cetiosaurus medius*, as they recede from the trunk, which seems to indicate that the present gigantic marine Saurian must have had a capacious and bulky trunk, but propelled by a longer and more crocodilian tail, than in the modern whales. It is sufficiently evident, however, that, even in the present short segment of the tail, with the slight increase of length, there is a diminution of height and breadth of the centrum, and a still more obvious subsidence of the neural arch, as the vertebræ recede from the trunk. The third of these vertebræ is figured of the natural size in Tab. X. As compared with the dorsal vertebræ, the chief change of form is the subquadrate contour produced by a lateral extension and flattening of the lower surface of the centrum, which is more essentially distinguished by four hæmapophysial articular surfaces, two at the anterior and two at the posterior margins (Tab. X, *h*, *h*) of this inferior surface. The articular surfaces at both ends of the centrum are now slightly concave; and the anterior one, which was nearly flat in the dorsals, is here the deepest; it is one inch deep at the upper third of the surface.* The sides of the centrum at the upper half are concave both lengthwise and vertically, forming a wide depression below the transverse process; the middle part of the side begins to stand out and divide the upper from the lower lateral concavity, which character, being more strongly developed in the hinder caudal vertebræ, gives the rhomboidal or hexagonal form.† The lower half of the side of

* The same modification of the articular extremities occurs in the caudal region of the vertebral column of the *Plesiosaurus*. See 'Report,' part i, 'Trans. Brit. Assoc.' 1839, p. 58.

† It is one of these posterior caudals of the *Cetiosaurus* which is figured as the type of the "second vertebral system" in the 'Geology of the South-east of England,' p. 296, fig. 2.

the centrum is less concave than in the dorsal vertebræ. The broad inferior surface is also less concave antero-posteriorly than in the dorsal vertebræ, and is nearly flat transversely; it gradually contracts, in the transverse direction, in the posterior caudals, so as to take on the form of a longitudinal sulcus. The two anterior hæmapophysial surfaces are separated from each other by an interval of two inches; the two posterior surfaces, which are larger than the anterior ones, are similarly distinct.

In the anterior as well as posterior caudal vertebræ of the *Iguanodon* the hæmapophysial surfaces are confluent on both the anterior and posterior parts of the under surface of the centrum, and the chevron bones accordingly present modifications by which they may, when detached, be distinguished from those of the *Cetiosaurus*. There was, however, as will be presently shown, another gigantic Saurian of the Wealden period, distinct from the *Cetiosaurus* and *Iguanodon*, but resembling the latter in the single hæmapophysial facet (Tab. XI).

The diapophyses, in the caudal vertebræ of *Cetiosaurus* (Tab. X, *d*), have descended, as usual, from the summit to the base of the neural arch in the anterior caudal vertebræ. They are short, compressed vertically, diminishing, and as if slightly twisted, so that the upper margin is turned forward, at their extremity. The vertical diameter of the base of the transverse process in the largest of the present caudal vertebræ is 3 inches; its antero-posterior diameter is 1 inch 6 lines; its length is 2 inches 7 lines: the extremity terminates obtusely. The upper ridge-like termination of the transverse process is continued to the base of the anterior zygapophysis. These processes (ib., *z*) are alone developed, as such, in the present vertebræ; the posterior articular surfaces (ib., *z′*) being impressed upon the sides of the posterior part of the base of the neural spine. The anterior zygapophyses project almost horizontally forward, diminishing, chiefly in vertical diameter, to an obtuse apex; convex externally, flattened internally by the oblong articular surface, and separated by a fissure nearly 1 inch wide: the length of these processes, from the bottom of the intervening fissure in the second of the four caudals, where they are most entire, is 2 inches. When the vertebræ are placed in juxtaposition, these processes reach beyond the middle of the vertebræ next in front, and pinch, as it were, the back part of the base of the spine so as to impress upon it the surfaces representing the posterior zygapophyses. These processes are well developed, on the contrary, in the corresponding vertebræ of the *Iguanodon*, and overhang the posterior surface of the body of the vertebra to which they belong. The spinous process, which appears to be nearly perfect in the second caudal, is short, strong, and truncated at the summit. Its height from the anterior oblique processes is 4 inches: the total height of the vertebra is 13 inches. The antero-posterior diameter of the side of the neural arch is 2 inches. The spinal canal is wider in these caudal than in the dorsal vertebræ, indicating the greater muscularity of the part deriving its nervous power from the corresponding part of the spinal cord: its transverse diameter is 1 inch

10 lines; its vertical diameter is 2 inches. The neural arch is, as usual in the present genus, anchylosed to the anterior part of the upper surface of the centrum: one inch and a half of this surface is left free behind the attachment of the arch. The finely wrinkled or fibrous character of the free surface is more strongly marked in these caudal than in the dorsal vertebræ.

In the three succeeding vertebræ the neural arch diminishes in height, the anterior articular processes diminish in length, and the posterior articular impressions in depth. The upper and lower parts of the sides of the body become somewhat more concave; the posterior articular surface grows flatter.

A detached chevron bone, 8 inches in length, consisting of two hæmapophyses, anchylosed only at their distal or inferior extremities, and with their distinct proximal ends more divaricated than are the confluent ones in the *Iguanodon*, corresponds with the caudal vertebræ here described, and doubtless belongs to the *Cetiosaurus brevis*.

The following are dimensions taken from the four caudal vertebræ above described:

	1st.		2d.		3d.		4th.	
	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.
Antero-posterior diameter of centrum	3	9	4	2	4	3	4	3
Transverse diameter of centrum	7	2	7	1	6	9	6	4
Vertical diameter of centrum	6	10	6	8	6	0	6	0

Of the present species of *Cetiosaurus*, I have examined specimens of the bodies of one dorsal and three posterior caudal vertebræ in the collection of Gilpin Gorst, Esq., which were obtained from the central strata of the Wealden, near Battle Abbey, commonly called the "Hastings beds."

The dorsal centrum closely agrees with those in the Mantellian Collection: its anterior surface is, as in them, nearly flat, or slightly convex; the posterior surface is concave.

	Inches.	Lines.
The antero-posterior diameter	3	2
The transverse diameter of the anterior surface	5	3
The vertical diameter of the anterior surface	5	2

The neurapophyses, with an antero-posterior extent of base of 2 inches 3 lines, are continuously anchylosed with the centrum, and leave about three quarters of an inch of the posterior part of the centrum free. The floor of the spinal canal is horizontal lengthwise; its transverse diameter 1 inch 3 lines.

The posterior caudal vertebræ present an antero-posterior diameter of nearly 4 inches, with a breadth of 3½ inches, and a depth of 4 inches, measuring to the lower part of the posterior hæmapophysial surface. The antero-posterior length

of the base of the neurapophysis is 2 inches 2 lines; and it does not begin so close to the anterior part of the centrum as in the dorsal vertebra. There are no posterior zygapophyses. The upper and lower portions of the side of the centrum are more distinctly separated by the comparative projection of the middle part, which gives the obscurely hexagonal form to these vertebræ. The inferior parts are most concave, and converge to form the sides of the longitudinal sulcus, to which the inferior surface of the centrum is reduced at this part of the tail. It is plain, from these modifications of the vertebræ, that the tail must here have presented the compressed Crocodilian type; and it is satisfactory to have these indications of the Saurian affinities of the present gigantic fossil, in consequence of the very close approximation of the larger vertebræ to the Cetaceous type. The vertical extent of the osseous basis of the tail was here augmented by strong hæmapophyses, which have left more prominent articular facets on the under part of the centrum than in the larger anterior caudal vertebræ: these facets, instead of being in pairs, as in the anterior caudals, approximate, and become confluent in the vertebræ of between 3 and 4 inches in breadth.

Occasionally the hæmal arch is found anchylosed to the posterior of these so confluent hæmapophysial surfaces, as in the posterior caudal vertebra figured in Tab. V, figs. 3 and 4.

A vertical section, through the middle of a dorsal vertebra, from that part of the back where the rib has ascended to articulate wholly with the diapophysis, well displays this characteristic modification of the articular parts of the centrum, in *Cetiosaurus* (Tab. IX, fig. 2). The same section shows the closer cancellous texture of the centrum near those articular ends; the more open texture, with a general tendency to a longitudinal course of the cancelli, in the middle; and the still more open and irregularly disposed cancellous structure at the base and back part of the neural spine.

From the foregoing data it may be inferred that there existed, at the period of the deposition of the Wealden, a Saurian reptile of dimensions at least equalling those of the *Iguanodon*, but with modifications of the vertebral column, from the middle of the back to the tail, departing from the Dinosaurian and approaching to the Crocodilian type. If, as is very probable, the cervical and anterior dorsal vertebræ above described (pp. 22—26, and provisionally referred to *Streptospondylus*), belong to the same reptile as the succeeding vertebræ, here referred to *Cetiosaurus*, we should then have a gigantic Crocodilian of the peculiar transitional type, as between that order and the Dinosaurian, which is manifested by the second "Honfleur Gavial" of Cuvier; *i. e.*, with convexo-concave vertebræ at the fore part of the trunk, graduating into plano-subconcave vertebræ, with elevated and somewhat complex neural arches, at the middle and back part of the trunk, and with vertebræ subconcave at both ends, in the tail.

Of the nature of the sacrum and pelvis in the present genus nothing definite and assured is at present known. Such proportions of the entire skeleton of one and the same individual as have imparted our present knowledge of the *Iguanodon* and *Megalosaur*, have not yet been discovered of the *Cetiosaurus*. Certain co-existences in relation to strata and localities, but hardly amounting to juxtaposition, indicated that the tibia and some other limb-bones of the Reptile with Cetiosaurian vertebræ were without a medullary cavity, and with the centre occupied by a coarse cancellous tissue.*

At the period when the vertebræ of this type were first discriminated from the veritable ones of the *Iguanodon*, I had not met with this characteristic structure of Cetiosaurian limb-bones in strata above the Portland Stone (Middle Oolite). They have since been found in the Wealden strata.

The late Dr. Mantell, in his Memoir on the *Pelorosaurus*, states: "I have a series of bones from Brook, in the Isle of Wight, through the kindness of my distinguished friend, Sir R. I. Murchison, proving the existence of *Cetiosauri* in the Wealden; all the long bones are destitute of a medullary cavity."†

A somewhat crushed femur of *Cetiosaurus longus*, measuring 4 feet 3 inches in length, from the Middle Oolite at Enslow Bridge, Oxfordshire, is preserved in the Geological Museum at Oxford: it does not show any medullary cavity. The specimens of Cetiosaurian long bones, from Wealden strata, which have hitherto come under my observation, are fragmentary. It is probable that parts of the coracoid and pubic bones, also from the Wealden, indicating a greater relative breadth of those elements of scapular and pelvic arches, than in true *Crocodilia*, but differing in form from the answerable bones in known *Dinosauria*, may have belonged to *Cetiosaurus brevis*, Ow.

The suppression of the species so named by me has been proposed, and its appropriation by another has been attempted,‡ under the name of *Cetiosaurus Conybeari*, Melville, "in order to prevent confusion and to remove the objection that may well be raised against the *nomen triviale* '*brevis*;'" "for who will venture," asks the appropriator, "to indicate the relative length of an animal with no known affine, from four of its anterior caudal vertebræ?"

Believing that the generic affinity of the *Cetiosaurus brevis* with *Cetiosaurus longus* and *Cetiosaurus medius* to have been demonstrated, I ventured to suggest, in 1841, that the *nomen triviale* might be found appropriate in reference to the relative length of the entire body, from what was then known "of the constancy and regularity of this dimension" (viz., length of vertebral centrum) "in the back bone of

* 'Report on British Fossil Reptiles,' 1841, p. 102.

† 'Philosophical Transactions,' 1850, p. 381.

‡ Ibid., 1849, p. 297.

individuals of the same species of Saurian." Subsequent experience of this constancy in the dorso-lumbar and caudal regions of the spine in *Crocodilia* and *Dinosauria* has confirmed me in that opinion. But I expressly stated, when proposing the specific names of the different species of *Cetiosaurus*, that those names referred "to the relative length of their vertebræ."* The highest authorities in palæontology had sanctioned this system of naming species from characters of instructive parts. And no naturalist appears to have supposed that the *Palæotherium latum* of Cuvier had necessarily a trunk as broad in proportion as the foot, or that the whole frame of *Anoplotherium obliquum* was askew. The *Raia spiralis* of Münster was not a twisted Skate, any more than the *Otodus ramosus* of Agassiz was a branched Shark. As to the plea of preventing confusion by changing the published name of an adequately defined species, competent naturalists concur in denouncing the practice, as being the chief cause of the present grievous confusion in zoological synonymy.

The objections to the species *Cetiosaurus brevis*, and a subsequent attempt to suppress the genus, call for notice here on account of their admission into volumes of so high a scientific repute as the 'Transactions of the Royal Society.' The reporters on the papers by Drs. Melville and Mantell must have assigned some value to the remarks which here receive the explanation from the author against whom they were directed.

Genus—Pelorosaurus, *Mantell.* Tab. XI, XII.

When publishing condensed descriptions of the previously undescribed, and for the most part undetermined, fossil remains of *Reptilia*, in my 'Reports' on that class submitted to the British Association in 1840 and 1841, it was known that the drawings made by aid of the grant voted for that purpose by the Association would subsequently be published in the work or monographs containing the more complete history of those British Fossil Reptiles. Reduced figures of the vertebræ, ascribed to *Cetiosaurus brevis*, and described in pp. 95—100 of the 'Report' of 1841, were, however, published, by anticipation, in the 'Philosophical Transactions' for 1850; the author quoting a remark by Sir J. G. Dalyell, that "delineation should be the inseparable accompaniment of description in natural history" (tom. cit., p. 382), and citing the descriptions in detail of these vertebræ, given "by Dr. Melville, in the 'Philosophical Transactions,' 1849, p. 296."

* Report, 'Trans. Brit. Assoc.,' 1841, p. 102.

On referring to that volume and page, however, I find the description limited to a partial quotation from my 'Report,' with the acknowledgment that "the four huge caudal vertebræ already mentioned as assigned to the *Cetiosaurus brevis*, exhibit very peculiar characters, fully detailed by Professor Owen."

The only objection offered by Dr. Melville is to the "nomen triviale" of the species to which they were assigned, and to which objection the reply has been given above. The subsequent proposal to suppress the "nomen genericum" was made under the following circumstances. In 1847 there was discovered, in the Wealden of Tilgate Forest, Sussex, the limb-bone, measuring 4 feet 6 inches in length, regarded as a "humerus" by Dr. Mantell, and, on account of its difference of form from that bone in the *Crocodiles*, *Iguanodon*, and *Hylæosaurus*, and its large medullary cavity, referred to a genus distinct from all then known Wealden Saurians under the name of *Pelorosaurus*.*

This unique fossil bone, of truly extraordinary size viewed as a humerus, was obtained by purchase, for the British Museum, after the demise of Dr. Mantell; and with it a number of large vertebræ, most of them from the caudal region, marked *Pelorosaurus*, were purchased at the same sale.

These vertebræ, now bearing the Museum numbers 28.627, 28.633, 28.634, 28.635, 28.653, 28.654, 28.655, 28.656, 28.657, correspond in colour and mineralized condition with the large, hollow long-bone. The original Mantellian labels, in the same handwriting, ascribing them to *Pelorosaurus*, have been scrupulously preserved, as they were attached to the specimens. It may, therefore, be inferred that they belonged, in the opinion of Dr. Mantell, to the genus and species which he established in the 'Philosophical Transactions' for 1850. Accordingly, the best preserved of these vertebræ is here figured, of the natural size, in Tab. XI, as the type of the anterior caudal vertebræ of *Pelorosaurus*, and the foregoing details are given in support of this ascription; because, singular as it may appear, not any of the vertebræ, marked *Pelorosaurus*, and preserved by Mantell, with the enormous limb-bone, in his private museum, as long as he lived, are figured, described, or even alluded to in his memoir on that genus; whilst he assigns to the base of the tail of his *Pelorosaurus*, the four vertebræ which were obtained by the British Museum, in the purchase of the first Mantellian Collection, in 1839, which were entered as vertebræ of the *Iguanodon* in the catalogue then prepared by the vendor, and on which I founded, in 1841, the species of *Cetiosaurus*, distinguished as *brevis*, from the longer Cetiosaurian vertebræ of older Oolitic strata.

A glance at the vertebræ figured of the natural size, and from the same

* Πέλωρ, monster, σαῦρος, lizard.

aspect, in Tab. X and XI of the present Monograph, will suffice to satisfy even a superficial comparative osteologist that they must belong to different species, if not genera, of Saurians. They are both from that anterior part of the tail where the vertebræ still retain the zygapophyses and send off the transverse processes (dia-pleur-apophyses, *d-pl*) from the base of the neural arch at its junction with the centrum: they are nearly, if not quite, homologous vertebræ. If No. 28.633 (Tab. XI) belonged, as its original possessor had marked it, to his genus *Pelorosaurus*,—No. 10.390 (Tab. X) of the earlier collection of fossils, originally marked *Iguanodon*, could not belong to the same genus.

It will be presently shown that the caudal vertebra (Tab. XI) marked *Pelorosaurus* by Mantell in his latest collection of fossils, although much more like the corresponding vertebra of *Iguanodon* than is the vertebra (Tab. X) so called in the first Mantellian collection, yet presents such differences as might have justified a generic separation from *Iguanodon*, if even the indication of the distinct genus of huge Wealden Saurian had not been afforded by the hollow limb-bone of 4½ feet in length.

The generic distinction of the above-cited vertebra from the first collection (Tab. X), selected by Mantell, in his memoir of 1850, to illustrate the vertebral characters of the new genus *Pelorosaurus*, founded on the later acquired fossil limb-bone, is much more strongly marked as compared with *Iguanodon*, or with the anterior caudals marked *Pelorosaurus* in the last collection.

In 1850, therefore, the persevering investigator of the geology of the South-East of England had evidence of two gigantic genera of Wealden *Reptilia* distinct from his *Iguanodon*, afforded by vertebræ, and he possessed also similar evidence afforded by bones of the limbs.

Those of the latter which were destitute of a medullary cavity he unhesitatingly referred to my genus *Cetiosaurus*, and he founded upon the long-bone with the medullary cavity the genus *Pelorosaurus*; but, with respect to the vertebræ, he chose to select for the *Pelorosaurus* those that had been previously demonstrated by me to present the Cetiosaurian character.

Pelorosaurus Conybearii.

The anterior caudal vertebra (Tab. XI) differs from the corresponding vertebræ of *Iguanodon*, and is here referred to *Pelorosaurus*, on the authority of the Mantellian label, according to which it was purchased as belonging to that genus, and is so entered in the Register of the British Museum, under the number 28.633.

the *Pelorosaurus*, in the 'Transactions of the Royal Society' for 1850; but, unfortunately, the mistake of the anterior for the posterior surface of the bone—viewed as a humerus—in that memoir, vitiates the description, and must have added to the difficulty of comprehending, and to the doubts respecting, the nature of the bone, felt by the anatomists acquainted with it only by the figures and text in the 'Philosophical Transactions.' It may be that some transposition and misarticulation of the skeleton of the Gavial, in the museum of the eminent physiologist, whose aid Dr. Mantell acknowledges, occasioned the mistake. According to the analogy of the humerus of the Crocodile, the posterior contour of the shaft of the bone is concave above, convex below; but in a less degree in the *Pelorosaurus*. This longitudinal concavity would, however, be more marked in the specimen had the posterior part of the head (wanting at *a*, figs. 1 and 3) been preserved, and had the three pieces in which this half of the shaft was extracted from the matrix been a little more naturally joined together. The proximal end of the bone is transversely oblong, moderately convex, with both anterior and posterior borders broken away, but leaving the latter more prominent and convex. The internal angle or tuberosity (*i*), which, if entire, would have confirmed so satisfactorily the determination adopted, is also broken away. A still larger proportion of the external side of the proximal end is wanting, leaving only the lower end of the deltoidal ridge (fig. 2, *d*). This, however, reaches three sevenths of the way down the bone, but subsides, and probably begins, nearer the proximal end of the humerus than in the Crocodiles. It projects forward, and bears the same relative position to the fore and outer parts of the bone in *Pelorosaurus* as in *Crocodilia*. The transverse concavity on the inner side of the deltoidal process is continued lower down upon the shaft of the bone of the *Pelorosaurus*, which shaft is more compressed from before backward, giving a longer and narrower sub-elliptical section (Tab. XII, fig. 4) than in the *Crocodilia*. Below the middle the shaft gradually expands to the distal end, the condyles of which project chiefly from the fore part of the bone, as in the Crocodile: they are, however, more unequally developed, the outer one (figs. 2 and 5, *c*) being much the largest.* There is an indication of a low ridge diverging to the outer and fore part of the outer condyle, as in the Crocodile.

At the back part of the humerus of the *Pelorosaurus*, the upper half shows a minor degree of longitudinal concavity, and a lower and more regular transverse convexity, than in the Crocodiles. There is a foramen for the medullary artery at the middle of the back of the shaft, where I have observed it in some *Crocodilia* (e. g. *Croc. Hastingsiæ*). At the lower half the surface, instead of being flat, is transversely concave at the middle, or more concave and with such channel more longitudinally extended, than in *Crocodilia*. The depth has been increased

* This character is rather exaggerated in fig. 2.

at one part by pressure. The medullary cavity of the bone is well marked, and bears to the compact wall the proportion shown in fig. 4, Tab. XII.

From the foregoing scanty data relative to the *Pelorosaurus*, and on the supposition of the long-bone being, as I believe it to be, a humerus, it may be inferred that there coexisted at the Wealden period, with the *Iguanodon*, *Megalosaurus*, and *Hylæosaurus*, a reptile of more Crocodilian affinities, and of a bulk at least equalling that of the largest of these *Dinosauria*.

In the characters of the best-preserved vertebræ—those, viz., from the base of the tail,—the *Pelorosaurus* most resembles the *Iguanodon;* and the differences here observable may not be of more than specific importance: the Crocodilian character of the humerus points, however, to a generic distinction.

From the *Cetiosaurus* the *Pelorosaurus* is more obviously and decidedly distinct, by vertebral characters, which, in regard to the latter genus, have now been, for the first time, pointed out.

The genera of Saurian reptiles, hitherto determined, from the Wealden strata, have been founded on vertebral characters. With these, in regard to two of the genera, viz., *Iguanodon* and *Megalosaurus*, corresponding generic distinctions have been yielded by the teeth. The same may be affirmed, with a high degree of probability, but not as yet with certainty, in respect of the *Hylæosaurus*. There is a fourth form of tooth, generically distinct from the foregoing, applicable in respect of size to either *Cetiosaurus* or *Pelorosaurus*.

Not any of the foregoing genera have been founded on the structure of the limb-bones; for, indeed, such structure is not generic. Some of these bones, for example, may be hollow, and others solid in the same limb of the same reptile. The femur of the *Cetiosaurus* might have a small medullary cavity, whilst the tibia, the fibula, and the metatarsal were cancellous in the centre. The generic distinction of this huge reptile was originally, and in every subsequent descriptions of its specifically differing remains, founded upon vertebral characters. The names of the species bear reference to the proportions and minor modifications of essentially Cetiosaurian vertebræ. If, therefore, the long-bone—most probably humerus—above described, should belong to the same species as the *Cetiosaurus brevis*, and not to the very distinct species established in the vertebræ marked *Pelorosaurus* by Dr. Mantell in his last collection, the medullary cavity of the Crocodilian bone would be no sufficient ground for suppressing the genus.

Neither, supposing the appearance of the cancellous centre of the equally long limb-bone of the great Saurian from the Bradford Clay at Enslow Bridge, Oxfordshire, to be due to compression, obliterating the medullary cavity, would that afford just and satisfactory ground for determining the genus of reptile to which the crushed bone belonged. The tibia of the correspondingly large reptile from the same formation and locality, originally deemed to be Cetacean, is, indeed, solid; but

it might have coexisted with a femur in which a small medullary cavity had been established. Compression proves nothing, however, as against the cancellous tissue of the centre of a bone: the force that would squeeze the medullary shaft of a Crocodilian femur 4 feet long, to a thickness of 3 or 4 inches, would overcome any resistance that the loose spongy texture of a Cetiosaurian bone would offer. Moreover, the shorter diameter of the humerus, referred by Dr. Mantell to *Pelorosaurus*, is but $4\frac{1}{2}$ inches; and the medullary cavity there, is most patent and perfect: such a cavity could scarcely have escaped the notice of so close an observer as the late Mr. Hugh Strickland, if it had really existed in the long-bone from Enslow Bridge, now in the Geological Museum at Oxford, and referred to the genus *Cetiosaurus*.

The satisfactory proof of the existence of remains of a huge species of Wealden Saurian distinct from *Iguanodon*, *Hylæosaurus*, *Megalosaurus*, and *Cetiosaurus*, is afforded by the vertebræ, one of which is figured, of the natural size, in Tab. XI. For this genus and species the name of *Pelorosaurus Conybearii*, may be most conveniently retained: most properly so, indeed, if ulterior discoveries should prove the hollow humerus to belong to a reptile with the Pelorosaurian type of vertebra.

In the descriptions of the vertebræ from the Wealden given in my 'Report' of 1841, and in the figures of them now published, the foundations, at least, may be laid for rightly reconstructing the huge and strange Reptilia to which they severally belonged.

Tooth of a large carnivorous Wealden Reptile.

A fossil tooth of a large reptile was discovered, some years ago, in the Wealden Clay of Brixton Bay, Isle of Wight, which differs from the similarly sized teeth of *Iguanodon* and *Megalosaurus*, and, therefore, most probably belongs to either the *Cetio-* or *Peloro-saurus*.

The crown of this tooth, measured along the greatest extent of enamel, is 2 inches: about 1 inch and 5 lines of the fang is continued beyond the crown. The fang is subcylindrical at its broken base, becomes compressed as it approaches the crown, and this expands, with a diminution of thickness, as it extends from the fang, for about one third of the length, where two opposite trenchant margins begin; after which it gradually contracts to a point.

The extreme breadth of the crown measures 1 inch; the thickness is 8 lines. On one side the crown is unequally convex; on the opposite side, at the apical two thirds, it becomes a little concave: one margin is gently convex, the other is very slightly concave. The convex side of the crown is covered by smooth enamel, which forms four low ridges on its most prominent part, and terminates inferiorly, by a

delicate rugous structure, in a well-defined border, concave toward the root. The opposite side of the crown, flattened below and concave above, has the enamel smooth, except at the base, where it is rugous, and is extended nearly half an inch lower down the crown, where it terminates by a border convex toward the root.

The margins of the crown are obliquely abraded toward the concave side of the crown, and, near the base of the straighter border, there is an oblique depression.

The root is subcylindrical, and shows the remains of a pulp-cavity: it appears as if it had been implanted in a complete alveolar cavity; but the unequal extent of the enamel on the two sides of the crown indicates a corresponding inequality in the outer and inner alveolar walls of the jaw which supported this tooth. Assuming the thecodont mode of its implantation, it would in this respect resemble the teeth of the Crocodiles, and of certain Enaliosaurs and Dinosaurs.

The shape of the crown of this tooth, especially the degree of compression of the crown and its expansion above the root into opposite borders, which become trenchant, accords best with the characters of the teeth in the carnivorous Sauria. Of such teeth as have hitherto been discovered in the Wealden strata, those that have been referred to the *Hylæosaurus** make the nearest approach to the form of the tooth in question; but, besides the difference of size, the crown has a more symmetrical shape in *Hylæosaurus*, and its broadest part is nearer the apex: the opposite worn margins which converge to the tip are both relatively shorter and thicker, and are not obliquely abraded so as to be trenchant, as they are in the larger Wealden tooth here described. It is a tooth of allied form to that of the *Hylæosaurus*, and, like it, was implanted by a cylindrical fang, apparently in a distinct socket: the few specimens that have been discovered of the teeth ascribed to *Hylæosaurus* appear to have been broken from the socket, not to have been naturally shed so as to show the traces of absorption; and the same is the case with the larger tooth in question.

The difference of form between the tooth of the *Megalosaurus*† and the present large piercing and cutting tooth is too obvious and strongly marked to need particularising; and it departs still further, both in shape and mode of implantation, from the tooth of the Iguanodon.‡

The present tooth, therefore, indicates a reptile equal in size to any of those above cited from the Wealden strata, but of a distinct genus: and vertebral evidence has been adduced, in the present 'Monograph,' of at least two genera—independently of *Streptospondylus*—of large Wealden reptiles equally distinct from those originally made known by Buckland and Mantell.

The tooth in question may, very probably, belong to either *Cetiosaurus* or *Pelorosaurus*. Future discoveries of teeth or of jaws with teeth, associated with the

* 'Monograph on Wealden Reptiles,' part iv, 1856, p. 21, Tab. VIII, figs. 6—9.

† Ibid., part iii, 1856, p. 21, Tab. XI and XII. ‡ Ibid., part i.

characteristic vertebræ of one or other of these large reptiles, will determine this question.

The tooth here described was first made known to geologists, and figured by Dr. Thomas Wright, F.G.S., an indefatigable explorer of the geology and fossils of the Isle of Wight, in a paper on the Palæontology of the Island, in the 'Annals and Magazine of Natural History' for August, 1852.

TAB. V.

Streptospondylus major.

Fig.

1. }
2. } Cervical vertebra, half natural size.

3. }
4. } Posterior caudal vertebra (*Pelorosaurus* ?), one fourth natural size.

From the Wealden of the Isle of Wight. **British Museum.**

TAB. VI.

Streptospondylus major.

Fig.

1. Upper view of cervical vertebra, half natural size.
2. Under view } of cervical vertebra, one sixth natural size.
3. Front view } of cervical vertebra, one sixth natural size.
4. Two anterior cervical vertebræ of a young Iguanodon, half natural size.
5. Side view of dorsal vertebra of *Streptospondylus major*, one sixth natural size.

From the Wealden of the Isle of Wight. British Museum.

Jo? Dinkel lith.

W. West imp.

Streptospondylus.

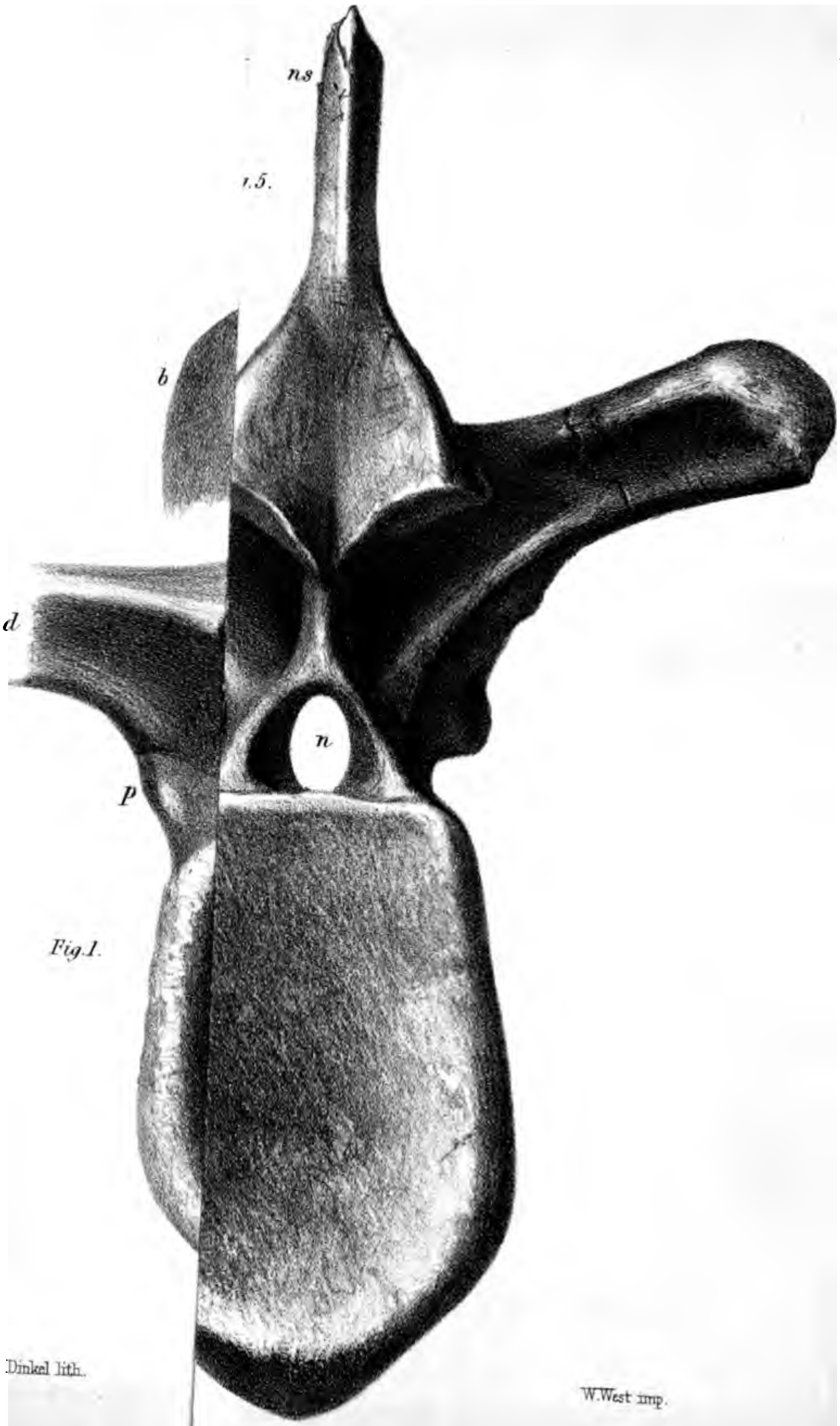
TAB. VII.

Dorsal Vertebræ of *Streptospondylus*, figs. 1, 2, 3 ; and *Iguanodon*, figs. 3, 4, 5 ; half natural size.

Fig.

1. Back view of centrum and base of neural arch.
2. Side view of base of neural arch.
3. Under view of centrum.
4. Back view of corresponding vertebra of Iguanodon.
5. Side view of base of neural arch.
6. Under view of centrum.

From the Wealden of the Isle of Wight. British Museum.



Jo? Dinkel lith.

W. West imp.

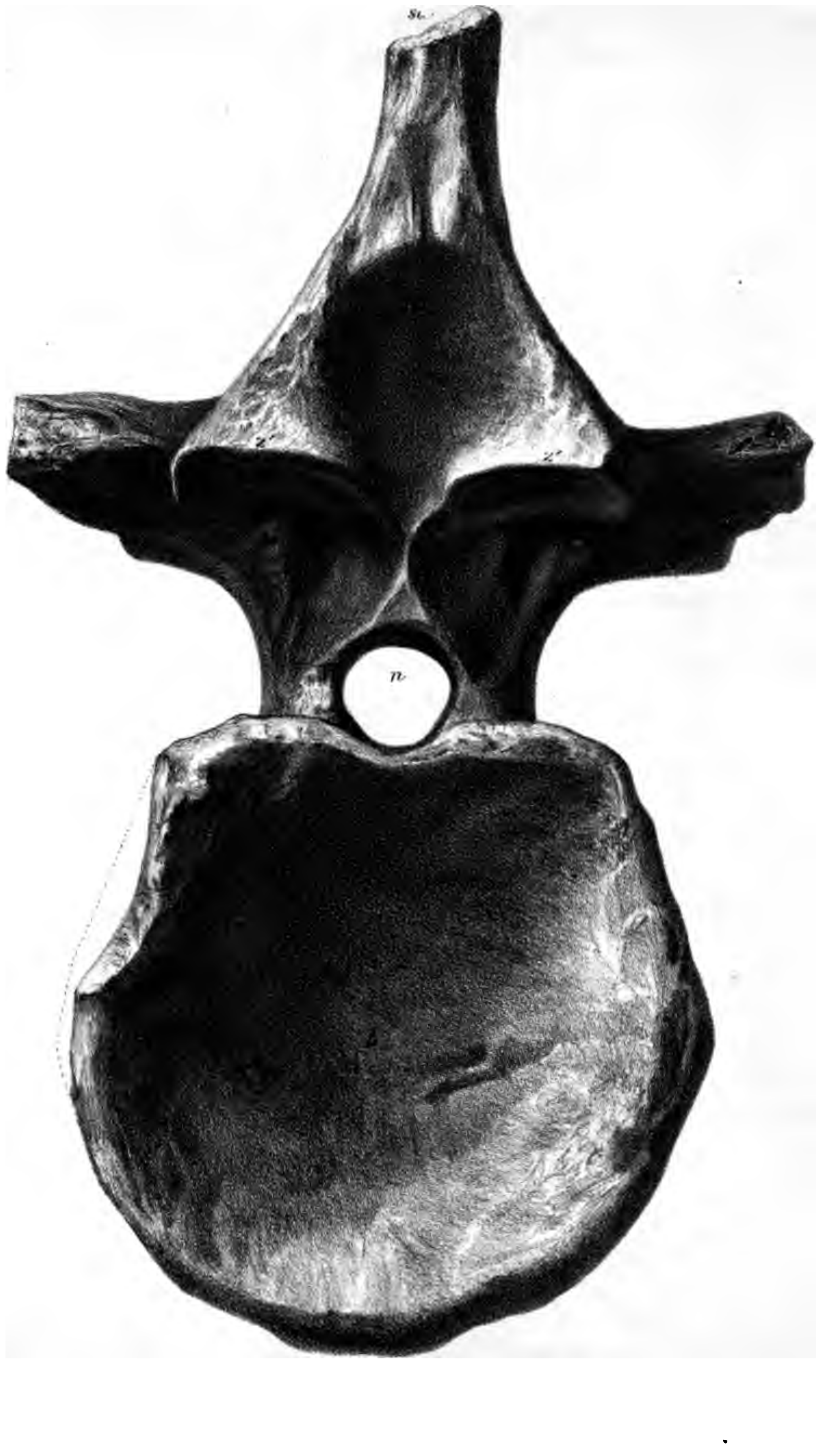
TAB. VIII.

CETIOSAURUS BREVIS.

Posterior view of a dorsal vertebra, half natural size.

From the Wealden of the Isle of Wight. British Museum.

1



inkel lith.

W. West imp.

TAB. IX.

CETIOSAURUS BREVIS.

Fig.

1. Side view of a dorsal vertebra, half natural size.
2. Vertical longitudinal section of a dorsal vertebra, half natural size.

From the Wealden of the Isle of Wight. British Museum.

Fig. 1.

Fig. 2.

Dinkel lith

W. West imp.

TAB. X.

Cetiosaurus brevis.

Posterior view of a caudal vertebra, natural size.

From the Wealden of Sussex. British Museum.

Jos Dinkel lith

TAB. XI.

Pelorosaurus Conybearii.

Posterior view of a caudal vertebra, natural size. The line below gives the antero-posterior dimension.

From the Wealden of Tilgate Forest. British Museum.

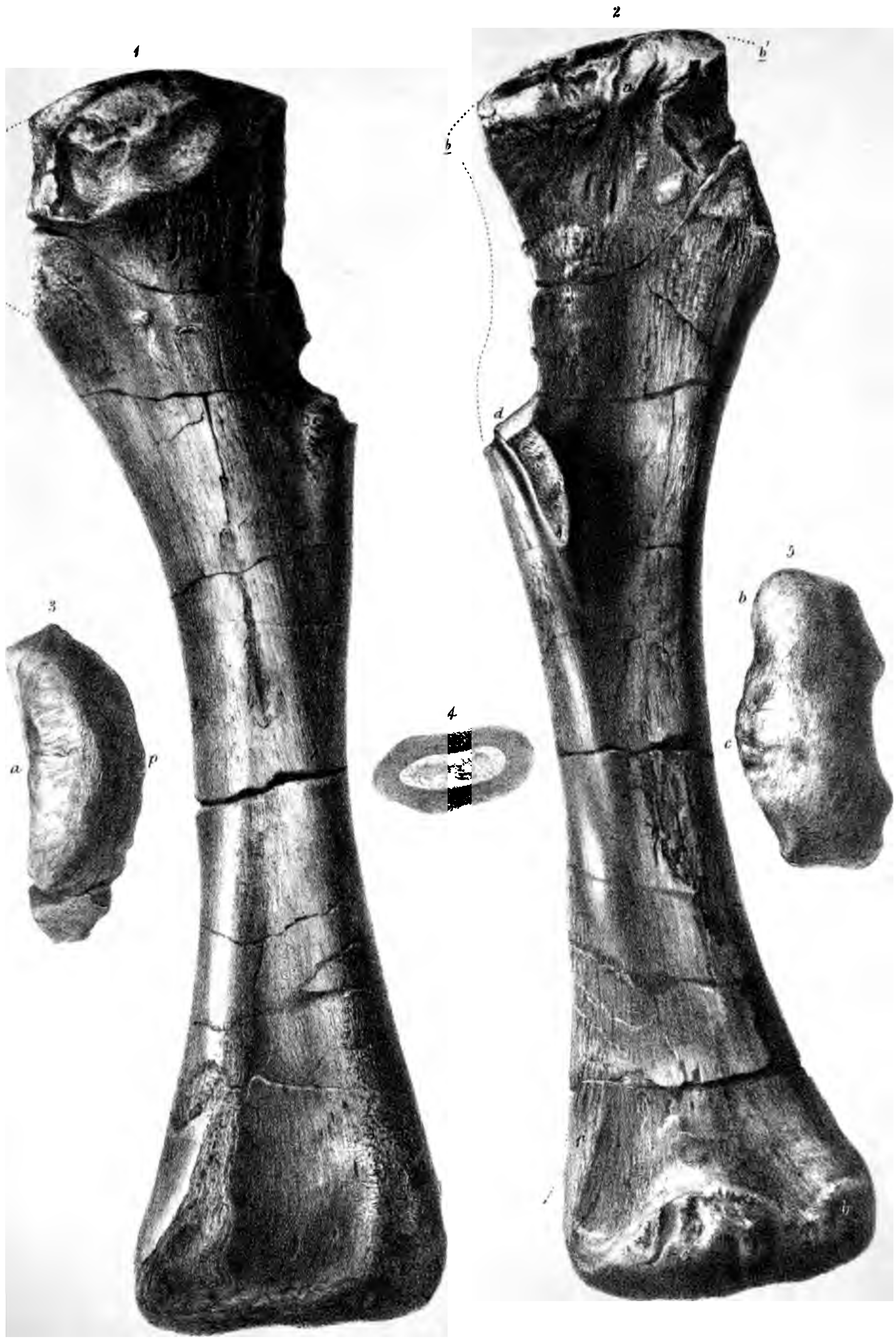
TAB. XII.

Right Humerus of *Pelorosaurus Conybearii*, one sixth natural size.

Fig.

1. Back view.
2. Front view.
3. Proximal end.
4. Section of middle of shaft, showing the medullary cavity.
5. Distal end.

From the Wealden of Tilgate Forest. British Museum.



W. West imp.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. III.

PAGES 19—21; PLATE X.

DINOSAURIA (IGUANODON).

[WEALDEN.]

BY

PROFESSOR OWEN, D.C.L., F.R.S., F.L.S., F.G.S., &c.

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1864.

counting from before backward. Each of these germ-teeth has the inner surface exposed of the summit of the crown, the anterior one showing the least proportion of the tooth. The primary longitudinal ridge (fig. 5, *a*) and the marginal serrations (*cc'*) are boldly and beautifully marked on the dark, lustrous enamel, the serrations being continued by grooves, some way upon the exposed inner side of the crown. The primary ridge more equally divides the summit of the crown here seen than in the part below, but the greater extent of the anterior area (*c*) is appreciable; the secondary longitudinal ridge (*b*) is discernible in both the anterior and posterior areæ of the crown, in the last two germs (fig. 1, 12, 14, and fig. 6. So much of the crown as appears in these teeth shows greater fore-and-aft breadth than the socket they would rise into, or rather than the socket of their predecessor, and the difference of breadth is so much greater in the basal part of the crown as to suggest much growth of the jaw in the progress of the germ to the state of a fully developed tooth in place. We thus obtain evidence of the immaturity of the specimen, and that it has not belonged to a distinct and diminutive species of *Iguanodon*.

Like all reptiles, the Iguanodon shed and renewed its teeth many times during the course of life; the new following the old teeth vertically, and being, therefore, in the growing animal, of a larger size than those they were about to displace. With the shedding of the deciduous teeth there was more or less absorption of their sockets, and with the rise of the successional teeth there was a concomitant formation of suitable, and, therefore, larger sockets.

In the Crocodile the number of teeth, or of sockets of one and the same set of teeth, does not vary with age, according to the observations of Cuvier.* Each tooth succeeds its forebear vertically, and none are added to the series, as in mammalia, from behind.

I believe myself able now to adduce evidence that the Iguanodon added this mammalian mode of succession to some other characters, which have been in previous Monographs pointed out, exemplifying its greater resemblance to the warm-blooded beasts than any existing form of reptile manifests.

The mandible of the young Iguanodon here described shows at the utmost fifteen sockets in the unquestionably entire series, occupying a longitudinal extent of four inches and a quarter. The mandible of the somewhat older Iguanodon, from the Wealden of Stammerham, Sussex, described and figured in my Monograph, 1855, Tabs. X and XI, shows eighteen alveoli, occupying a longitudinal extent of six inches.

* "Les dents offrent plusieurs remarques intéressantes dans le crocodile. La première, c'est que leur nombre ne change point avec l'âge. Le crocodile qui sort de l'œuf les a autant que celui de vingt pieds de long."—"Je me suis assuré de ce fait dans une série de huit têtes croissant en grandeur, depuis un pouce jusqu'à deux pieds." Cuvier, 'Ossemens Fossiles,' 4to, tom. v, pt. ii (1825), p. 90.

TAB. X.

Iguanodon Mantelli, nat. size.

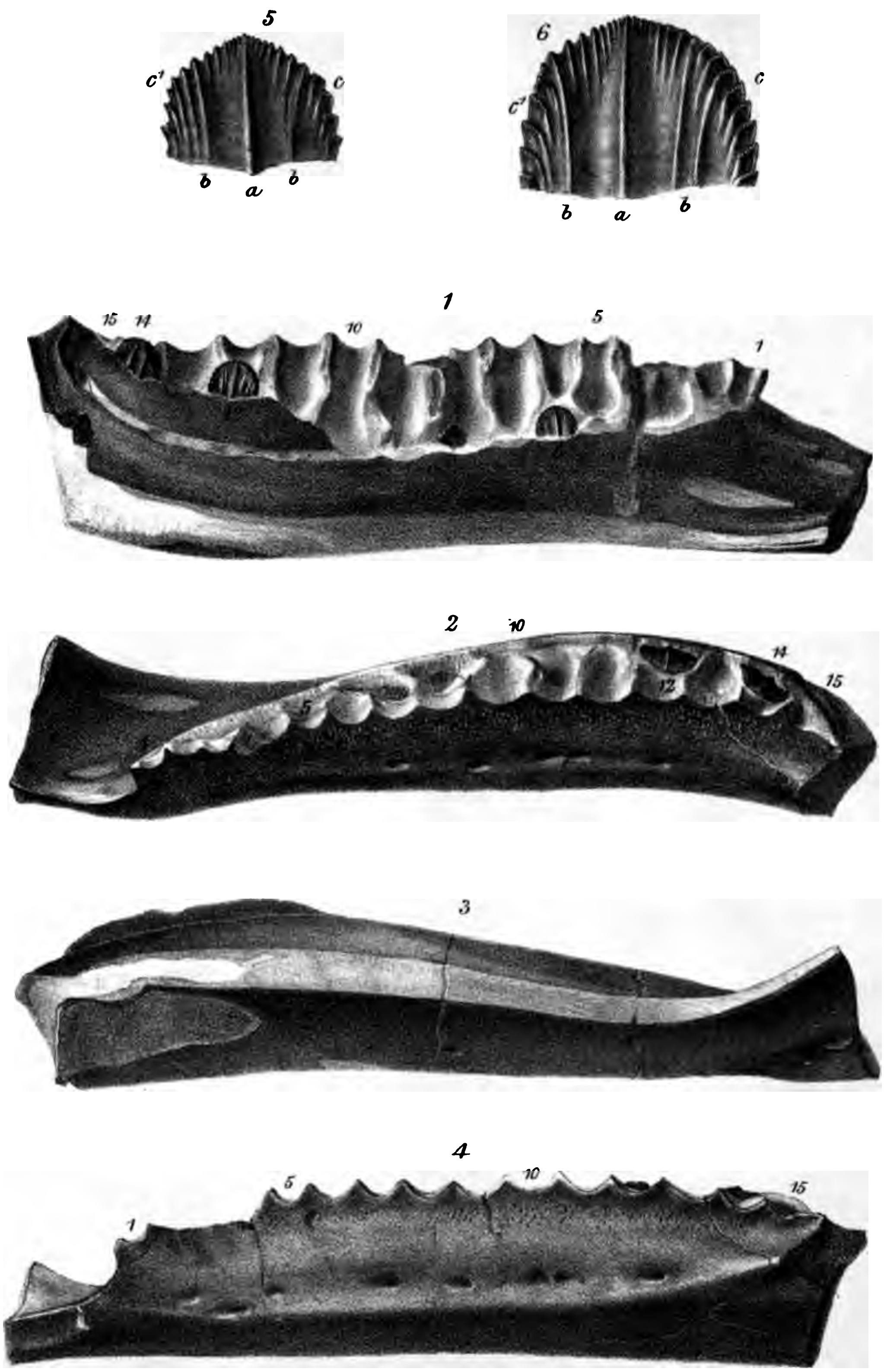
Fig.

1. Inner side of part of the left mandibular ramus, showing part of thin inner alveolar wall (12), of a young Iguanodon.
2. Upper view of ditto.
3. Under view of ditto.
4. Outer side of ditto.

In each figure, 1 to 15 indicate the alveolar depressions in the outer wall.

5. Inner side of apex of crown of the successional tooth (6, fig. 1), magnified.
6. Inner side of apex of crown of the successional tooth (12, fig. 1), magnified.

Discovered by the Rev. W. Fox, M.A., in the Wealden, near Brixton, Isle of Wight.



J. Dinkel del. et lith.

W. West imp.

YOUNG IGUANODON.